Chemical Processing and Equipment

Volume 6

SELECTED REFERENCE MATERIAL
UNITED STATES ATOMIC ENERGY PROGRAM

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Chemical Processing and Equipment

ATOMS FOR PEACE
UNITED STATES OF AMERICA

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Chemical Processing and Equipment

UNITED STATES OF AMERICA

GENEVA: AUGUST 1955

Foreword

Interchange of scientific and technical knowledge will greatly facilitate the work of the scientists and engineers whose skills will be devoted to the future development of the peaceful uses of atomic energy.

The United States has made available to the world's scientific community a large body of such data. In honor of this historic Conference and to stimulate further exploration and development of the beneficial applications of nuclear energy, the United States Atomic Energy Commission has prepared this special collection of technical data for the use of the delegates and the nations represented.

The purpose of this collection is to provide information concerning the ways that we have found in which fissionable materials can be put to work in nuclear reactors for research purposes and for the production of power and radioisotopes.

It is our sincere hope that this material will be of practical value to the men and women of science and engineering in whose hands the great power of the atom is becoming a benign force for world peace.

Lewis L. Strauss

Chairman, U.S. Atomic Energy Commission

Acknowledgment

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Contents

Chemical Processing of Reactor Fuel Elements at the Idaho Chemical Processing Plant

COMPILED BY NATIONAL REACTOR TEST STATION
PHILLIPS PETROLEUM COMPANY

Chemical Processing of Reactor Fuel Elements at the Idaho Chemical Processing Plant

It is not possible completely to burn up the fissionable material from the fuel elements in a nuclear reactor because the build-up of fission-product poisons, the depletion of the fissionable material, and the radiation damage to the elements eventually require their replacement. Economical operation of the reactor requires that the unconsumed fissionable material be recovered from the spent fuel elements. This section describes a successfully operating plant for the decontamination and recovery of fissionable material from fuel elements. Its purpose is to familiarize the reader with the problems connected with recovery operations and to give details of the process operations and plant facilities. As reprocessing operations must always be considered an integral part of any nuclear reactor research or power program, it is hoped that this information will be of value to those planning nuclear projects in the future.

The Idaho Chemical Processing Plant (ICPP) is designed to recover fissionable material from spent reactor fuel elements from various experimental and power-producing reactors in the United States. The plant is located at the National Reactor Testing Station near Idaho Falls, Idaho. The initial process development for the plant processes was carried out by the Oak Ridge National Laboratory (ORNL). The present operating contractor is the Phillips Petroleum Company of Bartlesville, Oklahoma.

This account is confined to describing the facilities, equipment, and process initially provided for uranium recovery from enriched uranium–aluminum alloy fuels such as those used in the materials-testing reactor (MTR) and the bulk-shielding reactor. Much of this equipment is, of course, adaptable to the processing of other types of fuels.

The high value of the uranium in the fuel elements demands that the process be capable of essentially complete uranium recovery. In addition, the process is required to effect nearly complete separation of the fission products from the uranium.

This plant is the first Atomic Energy Commission processing facility that has been designed for direct, rather than remote, maintenance. No provisions have been made for remotely controlled removal or repair of the process equipment. Thus, in the event of equipment failure or the necessity of modification, chemical solutions must be used to decontaminate the equipment before personnel can enter the process areas to carry out maintenance or construction work. As the radioactive solutions processed contain as much as 150 curies of radioactivity per liter, effective procedures for decontamination are an absolute necessity for the successful operation of this type of plant.

PROCESS

The process consists of three main steps: (1) dissolution of the uranium-aluminum elements in nitric acid, (2) adjustment of the dissolver solution to a composition suitable for solvent extraction, and (3) separation of the uranium from the aluminum, fission products, and transuranic elements with which it is associated in the fuel elements. The separation is accomplished by continuous liquid-liquid extraction employing methyl isobutyl ketone (hexone) as the solvent.

A schematic flow sheet of the process is shown as Fig. 1.

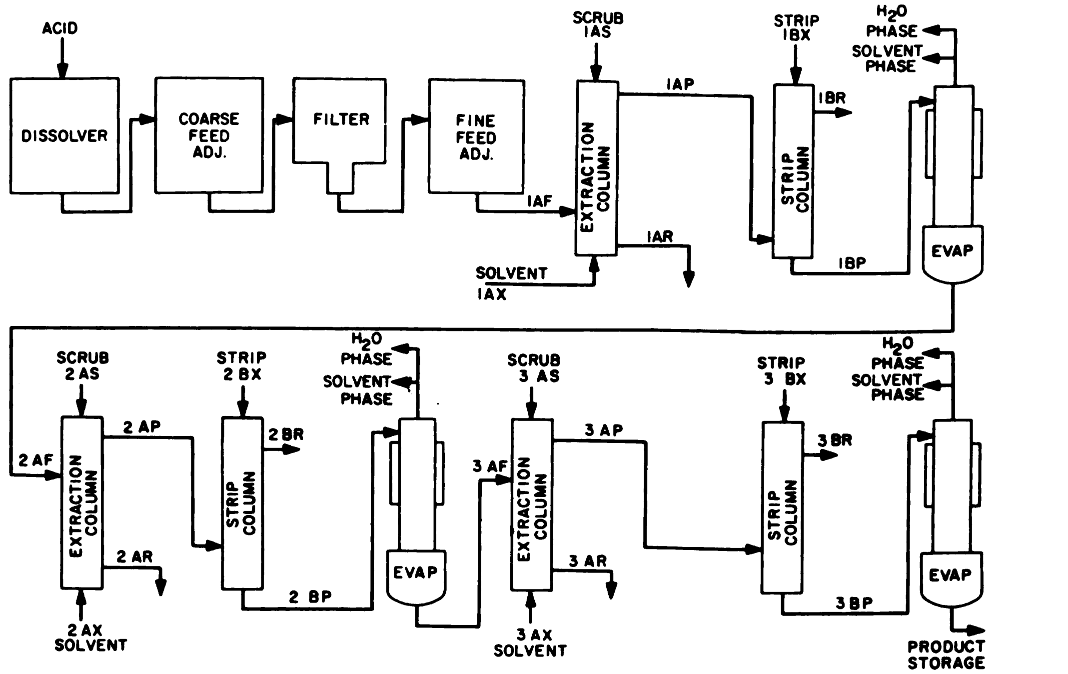


Fig. 1 Simplified feed preparation and extraction flow sheet.

Process Requirements. The process is required to recover greater than 95 per cent of the unconsumed uranium, produce a uranium product essentially free of plutonium, and reduce the fission-product activity to a level that will allow further processing of the uranium without shielding. In the case of MTR fuel, the fission-product concentration must be reduced by a factor of approximately 10^6. These requirements have been successfully met in all processing runs.

Fuel Cooling. At the time of discharge from a reactor, the fuel elements are intensely radioactive, owing primarily to approximately 100 short-lived fission products. It has been estimated that an MTR element will have about 2×10^8 curies of activity associated with it. This activity may be greatly reduced by storing (cooling) the irradiated elements and allowing these fission products to decay. Four days of cooling reduces the activity by a factor of about 10^3, and 135 days by a factor of 10^4. However, the activity that determines the minimum permissible cooling time is U^{237}, which is formed by neutron capture in U^{236}. It constitutes only a small fraction of the total activity at the time the irradiated fuel is discharged, but, since it is not possible to separate the isotopes of uranium during chemical processing, the fuel assemblies must be cooled until such time as the U^{237} activity in the recovered uranium is reduced to a low enough concentration to permit product handling and further processing without shielding.

Fuel Dissolution. The first chemical operation after cooling is the dissolution of the assemblies in nitric acid. Nitric acid dissolves finely divided aluminum quite readily, but, owing to the formation of passive surfaces of aluminum oxide, thick pieces of the metal are incompletely dissolved. The presence of mercury catalyzes the reaction of nitric acid with aluminum and allows complete dissolution, presumably owing to amalgamation and galvanic effects. Dissolving procedures for all fuel elements that contain aluminum include the use of mercuric nitrate as a catalyst. Dissolution of uranium metal in dilute nitric acid involves the primary reaction

$$U + 4HNO_3 \rightarrow UO_2(NO_3)_2 + 2NO + 2H_2O$$

The dissolution of aluminum in nitric acid involves a number of reactions which may be approximately summarized in the over-all reaction

$$Al + 3.7HNO_3 \xrightarrow{Hg} Al(NO_3)_3 + 0.15NO + 0.10N_2O + 0.175N_2 + 1.85H_2O$$

All the above reactions and others occur in the course of a normal dissolving, and it is difficult to predict accurately the composition of the gaseous reaction products. However, the acid consumption is always about 3.7 moles per mole of aluminum dissolved.

In addition to the gaseous reaction products shown above, volatile fission products are liberated during dissolution.

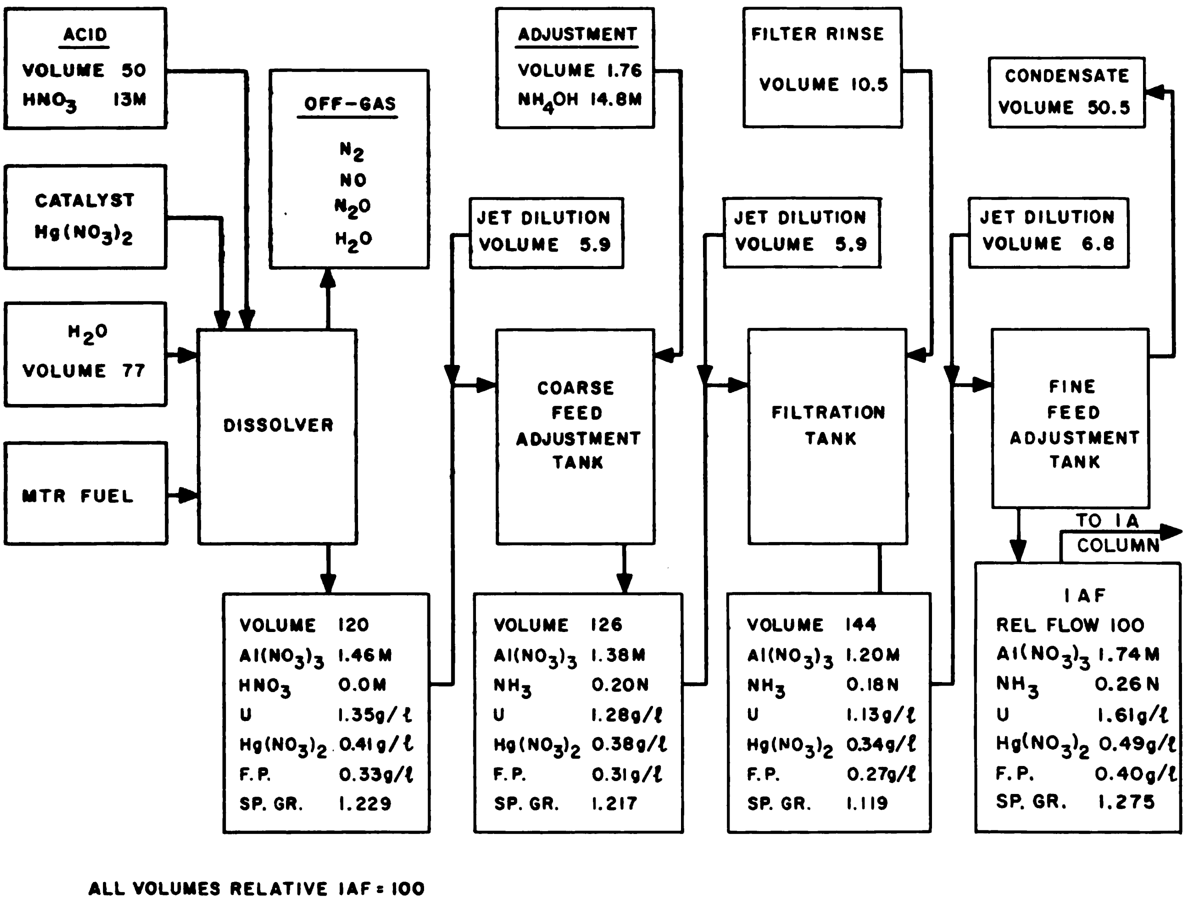


Fig. 2 MTR dissolution and feed preparation flow sheet.

MTR elements are dissolved in a batch operation as shown on the chemical flow sheet (Fig. 2). The elements are charged to the dissolvers and are dissolved in nitric acid (3.7 moles per mole of metal) containing a weight of mercuric nitrate equivalent to 1 per cent of the element weight. The dissolution is carried out at boiling temperature. MTR elements dissolve rapidly; and to control the reaction rate, only one-half of the acid is added initially and the balance is metered in over a 2-hr period. The dissolver batch is digested for a total period of 7 hr at boiling, at which time the dissolution is 100 per cent complete.

Feed Preparation. The solution from the dissolvers is adjusted to a composition suitable for extraction-column feed in the feed-preparation equipment. These operations are carried out in batches following the chemical flow sheet for MTR elements shown in Fig. 2. The equipment for these operations is shown in Fig. 3.

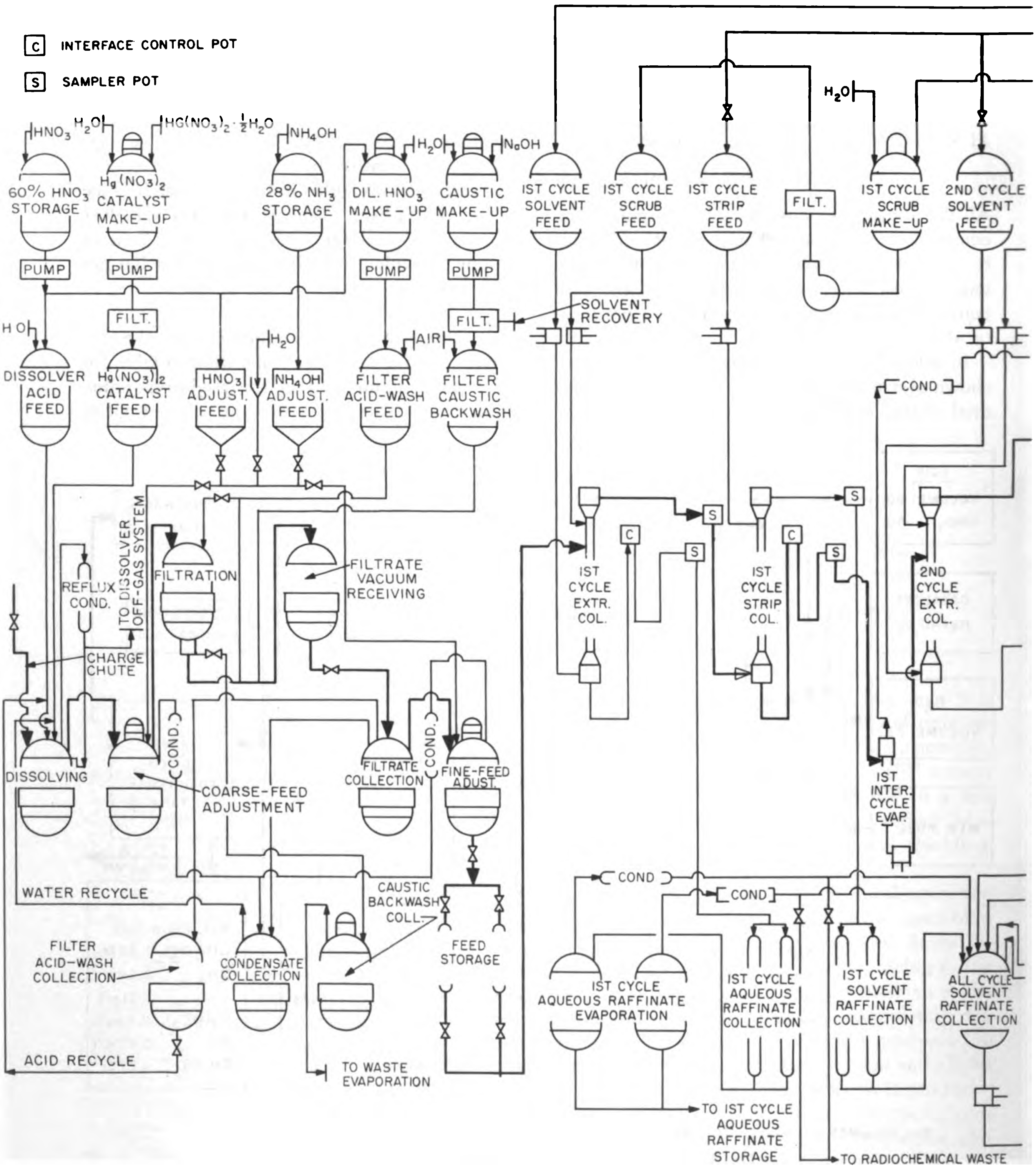


Fig. 3 Over-all process equipment flow

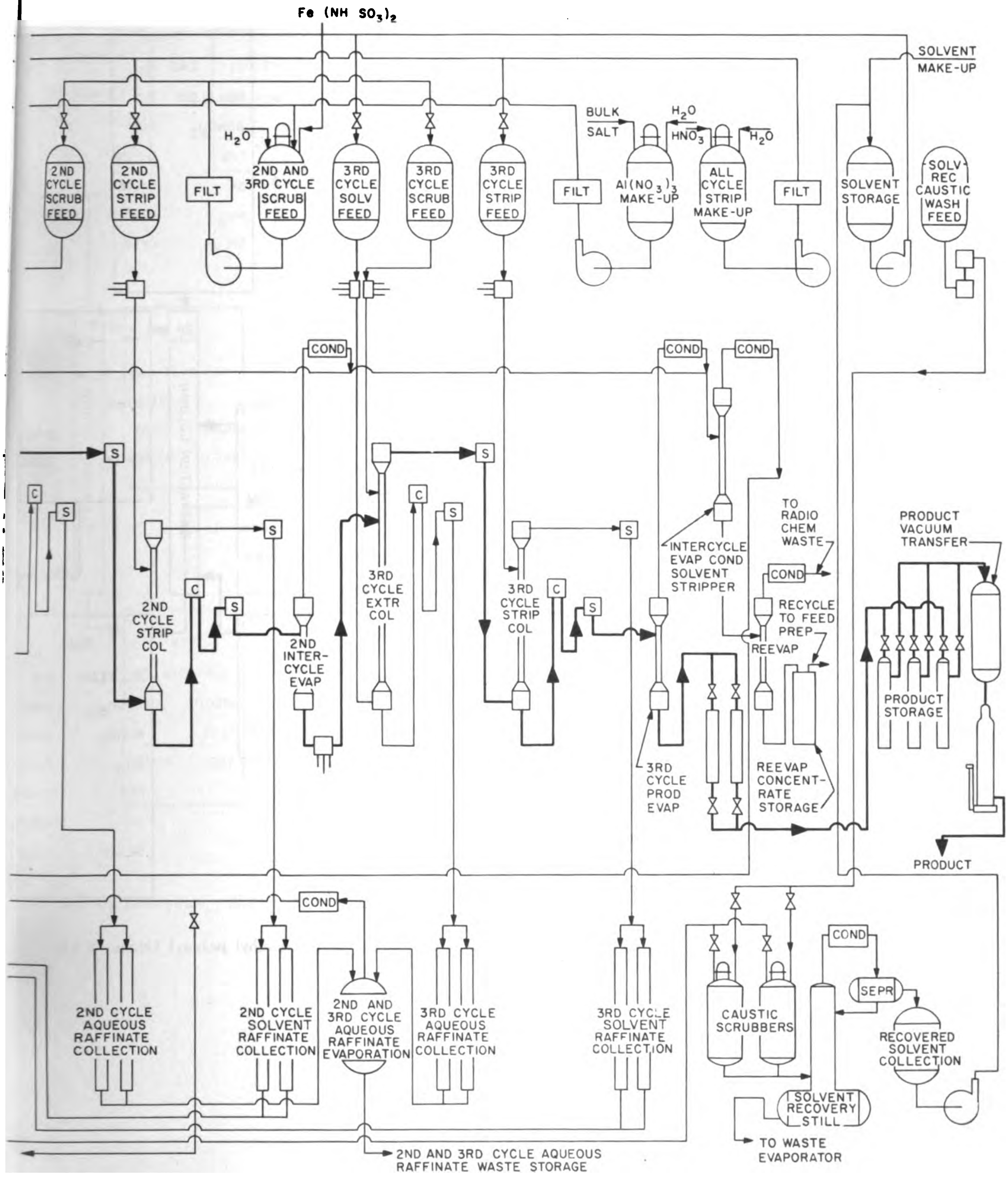


diagram for the Chemical Processing Plant.

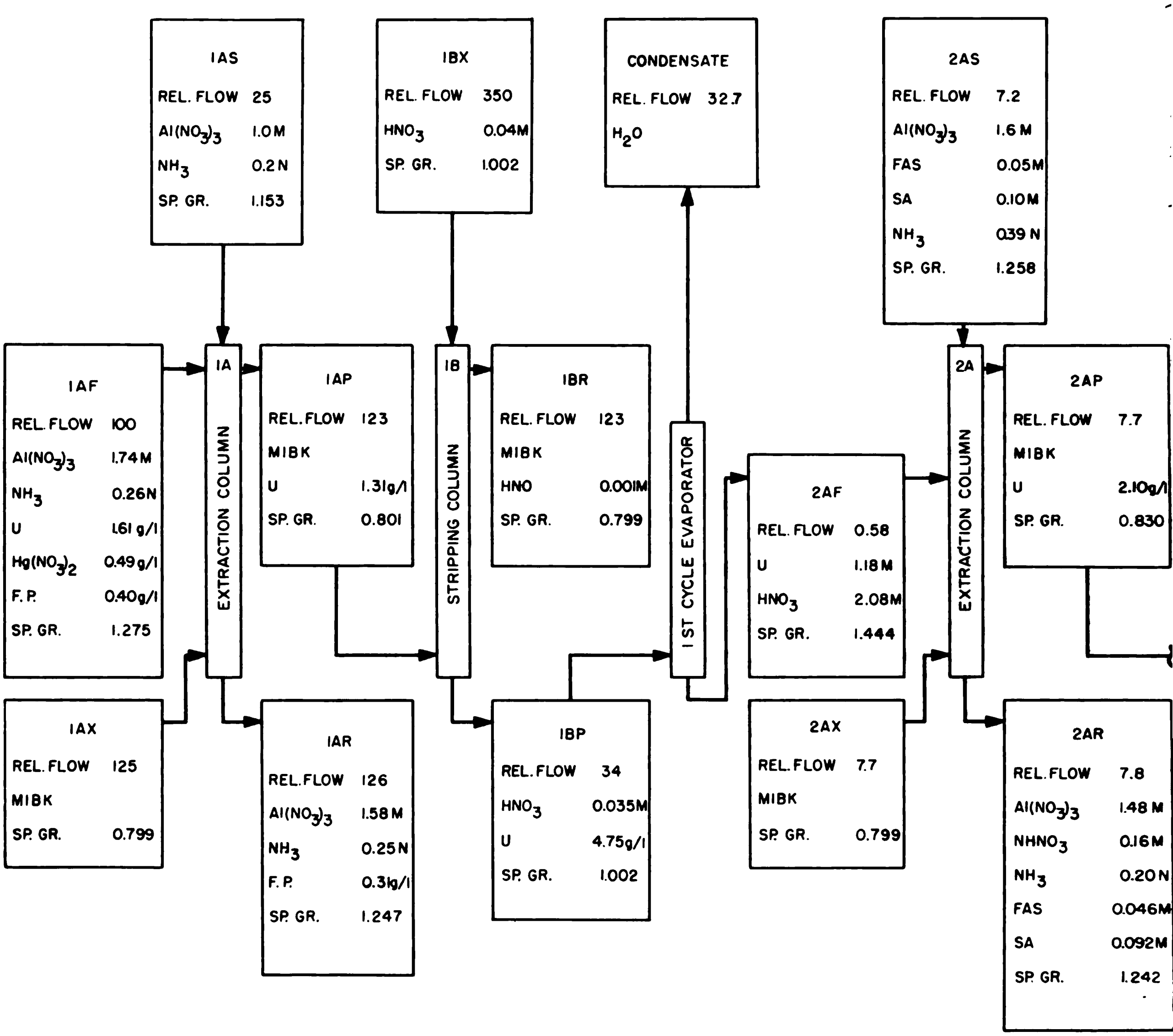
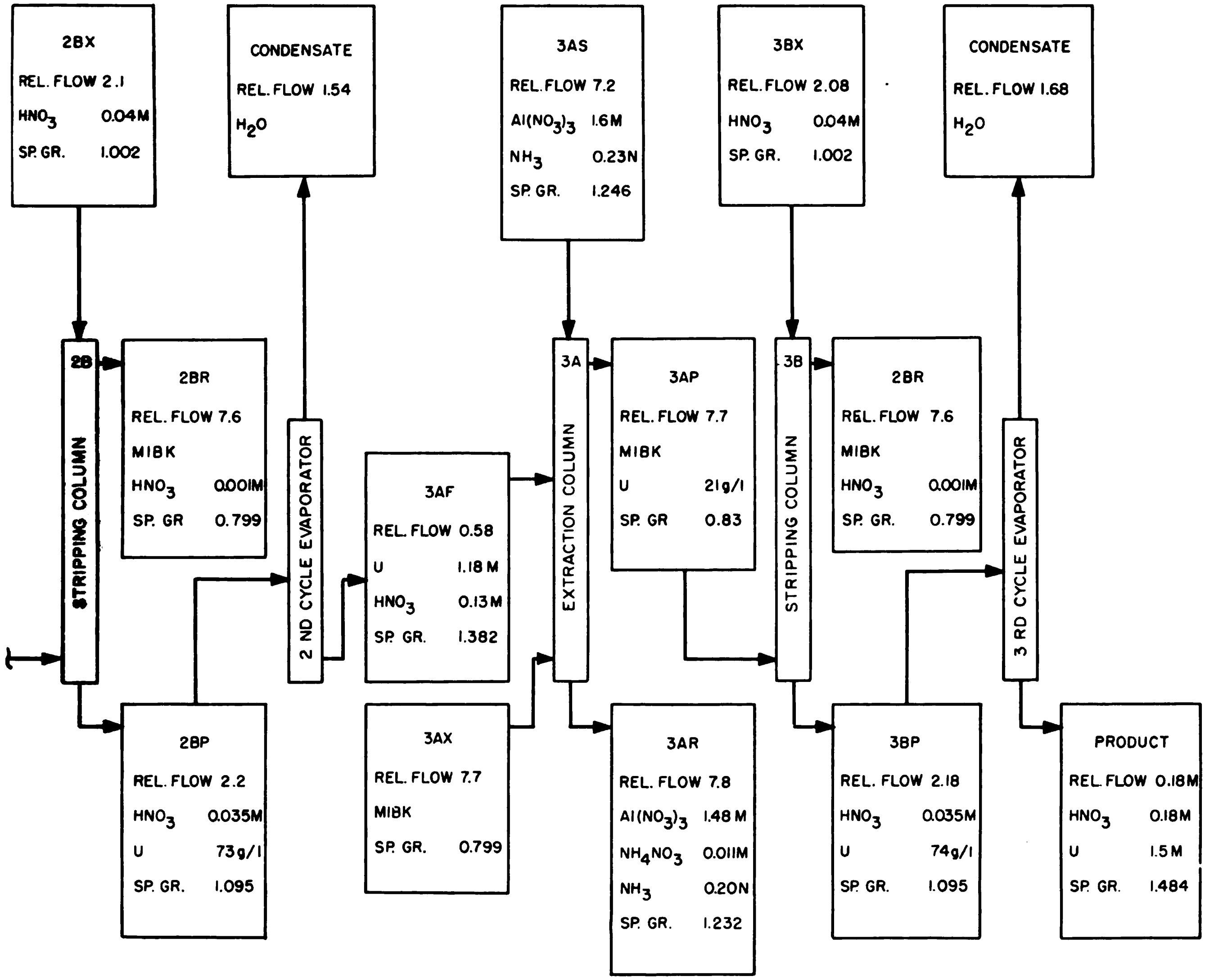


Fig. 4 MTR solvent extraction chemical flow sheet. MIBK, methyl isobutyl ketone; FAS, M, molarity; N, normality.



ferrous ammonium sulfate; SA, sulfuric acid; Rel Flow, all flows relative to IAF = 100;

The dissolver solution is sampled and analyzed for uranium, uranium mass distribution, acidity, and specific gravity in the coarse feed adjustment vessel. The uranium, uranium mass distribution, and specific gravity are used to calculate accurately the input of U^{235} into the plant. The acidity analysis is used to calculate the amount of ammonium hydroxide required to neutralize any excess acid.

The quantity of ammonium hydroxide required to make the final adjusted feed 0.26 normal acid-deficient is added, and the batch is agitated for 2 hr to dissolve aluminum hydroxide formed when the ammonium hydroxide is added.

Solid material in the dissolver solution, if present, is removed by filtration through a star-shaped stainless-steel sintered filter of 5 μ porosity. The filter has an effective area of 4 ft^2. Solutions from some types of fuel elements do not require filtration as the dissolver solution contains very little particulate matter.

A small amount of solids composed mainly of silica is present in MTR feed solutions from impurities in the aluminum and the brazing material used to fabricate the elements. Although the quantity of solids is very low, these solutions are difficult to filter because the particles enter and plug the pores of the filter element. Whenever the filtration time for a batch exceeds 5 or 6 hr, the element is cleaned by throughwashing with nitric acid, and then backwashing with sodium hydroxide and sodium fluoride.

After filtration, the feed solution is concentrated to the specific gravity required to provide an extraction salting strength equivalent to the aluminum nitrate and ammonium nitrate concentrations shown on the flow sheet. (One mole of aluminum nitrate is equivalent in salting strength to 7.5 moles of ammonium nitrate.) The solution is then sampled again and analyzed for acidity. Additional ammonium hydroxide or nitric acid is added, if needed, to bring the solution to 0.26 normal acid-deficient.

Solvent Extraction. Uranyl nitrate behaves as a strong electrolyte in aqueous solution, being almost completely dissociated into uranyl (UO_2^{++}) and nitrate (NO_3^-) ions. However, as an undissociated molecule, $UO_2(NO_3)_2 \cdot 3H_2O$, it is soluble in many organic solvents, including methyl isobutyl ketone. The introduction of a common ion, in this case NO_3^-, into the aqueous solution shifts the equilibrium toward the molecular form and enhances the extraction of uranyl nitrate by the solvent. The preferential distribution of uranium into methyl isobutyl ketone from a nitrate-salted aqueous solution is the basis for the solvent extraction process. Aluminum nitrate was the obvious choice as salting agent since, even though expensive, it is already present in high concentration in the MTR dissolver solutions.

The process for uranium purification by solvent extraction involves a series of extraction-stripping cycles. Uranium is preferentially extracted with methyl isobutyl ketone (hexone) from an aluminum nitrate solution in the lower section (extraction section) of the extraction columns. The bulk of the fission products remains in the aqueous phase since these fission products are considerably less extractable than uranium. The uranium-hexone extract rises to the upper section (scrub section) of the extraction column where additional fission-product decontamination is accomplished by scrubbing with a counterflowing stream of aluminum nitrate solution. Operation of the extraction columns under acid-deficient conditions, as shown on the chemical flow sheet (Fig. 4), has been found to improve significantly the fission-product decontamination over that realized with operation under acid conditions. The solvent, containing the uranium and some fission products, is brought into contact with dilute nitric acid in a second column, and the uranium and fission products are back-extracted (stripped) into the aqueous phase. A new feed is prepared from this solution by concentration in an evaporator, and the extraction-stripping cycle is repeated for additional separation from fission products. Three such cycles are required before the uranium is sufficiently free of fission products to permit handling without shielding.

Plutonium follows the same path as the fission products in the solvent extraction cycles. Plutonium (IV), the species present in the feed solution, favors the aqueous phase under the acid-deficient conditions of the MTR flow sheet. Thus the bulk of the plutonium leaves with the first-cycle aqueous-waste stream. A reducing

agent, either ferrous sulfamate or a mixture of ferrous ammonium sulfate and sulfamic acid, is added to the second-cycle scrub stream to reduce any remaining plutonium to the III valence state, which has an organic-to-aqueous distribution ratio of about 6×10^{-4} and thus is readily scrubbed out in the second and third cycles.

ator. The concentrate is recycled to the process through the salvage equipment.

The major features of the extraction and stripping columns used for processing MTR material are summarized in Table 1.

The columns are normally operated between 15 and 50 per cent of the theoretical flooding

Table 1 Solvent-extraction-column Features

Column	Theoretical flooding rate (both phases), gal/hr/ft^2	Packing (rings)	Extraction length, ft	Scrub length, ft
1st-cycle extraction	1200	$\frac{3}{8} \times \frac{3}{8}$ in.	27.5	9.9
1st-cycle stripping	620	$\frac{1}{4} \times \frac{1}{4}$ in.	20.0	
2d-cycle extraction	745	$\frac{1}{4} \times \frac{1}{4}$ in.	23.5	7.3
2d-cycle stripping	640	$\frac{1}{4} \times \frac{1}{4}$ in.	20.0	
3d-cycle extraction	745	$\frac{1}{4} \times \frac{1}{4}$ in.	23.5	7.3
3d-cycle stripping	635	$\frac{1}{4} \times \frac{1}{4}$ in.	20.0	

The chemical flow sheet for solvent extraction of MTR element feeds is shown in Fig. 3, and the process equipment is shown in Fig. 4.

The solvent-extraction system is continuous throughout the three cycles. The first-, second-, and third-cycle-product stream concentration is carried out continuously in critically safe thermosyphon-type evaporators before being fed to the succeeding extraction columns or storage as final product. The stream rate is automatically controlled by the evaporator liquid level, and the product outflow rate is controlled by the density of the evaporator solution.

All radioactive column feeds are pumped with remote-head stainless-steel-diaphragm metering pumps. The first-cycle feed rate is controlled manually; the second- and third-cycle feed rates are controlled automatically by the evaporator densities. Cold feed streams are fed by manually set metering pumps of standard design.

Flowing-stream samplers are provided on all waste and product streams in the extraction cycles for drawing samples for special process studies. These samplers are not used during routine operation.

Condensate streams from the intercycle evaporators are stripped of solvent and then reevaporated in a falling-film-type continuous evapor-

velocity, although they may be operated up to 80 per cent of flooding. The actual flooding rates of the extraction columns have been found to decrease during long runs owing to build-up of solids in the packing. These solids enter mainly with the cold scrub streams and can be eliminated by filtration through nonlinting filter paper.

Decontamination factors for each solvent extraction cycle for one period while processing MTR fuel are given in Table 2.

Table 2 Fission-product Decontamination Factors

Cycle	Decontamination factors	
	Beta	Gamma
First	9.5×10^3	3.76×10^3
Second	49.5	48.6
Third	5.6	7.0
3-cycle total	2.63×10^6	1.28×10^6

Product Handling. The product from the third extraction cycle is concentrated to 1.5-molar uranium and held up in storage vessels until

enough has accumulated for packaging. The product solution is packaged in a geometrically safe container, sampled, weighed, and sealed for shipment to another site for additional processing. The sample is analyzed for uranium, uranium mass distribution, beta and gamma radioactivity, and ionic impurities to determine accurately the contained amount of U^{235} and to determine if the product meets specifications.

Waste Handling. *Liquid waste.* A schematic flow sheet of the liquid-waste disposal systems is shown in Fig. 5.

content. If high in uranium, the waste is sent to the salvage equipment for recovery. Normally, the waste is concentrated to the minimum volume possible without freezing (ca. 2.2-molar aluminum nitrate) and is jetted from the Process Building directly to a 300,000-gal type 347 stainless-steel permanent storage tank. This tank is enclosed in a concrete vault buried under approximately 10 ft of earth. The fission-product heat in first-cycle raffinates is sufficiently high to require cooling; submerged stainless-steel coils and a reflux condenser are provided for this purpose. It is necessary to cool the large waste

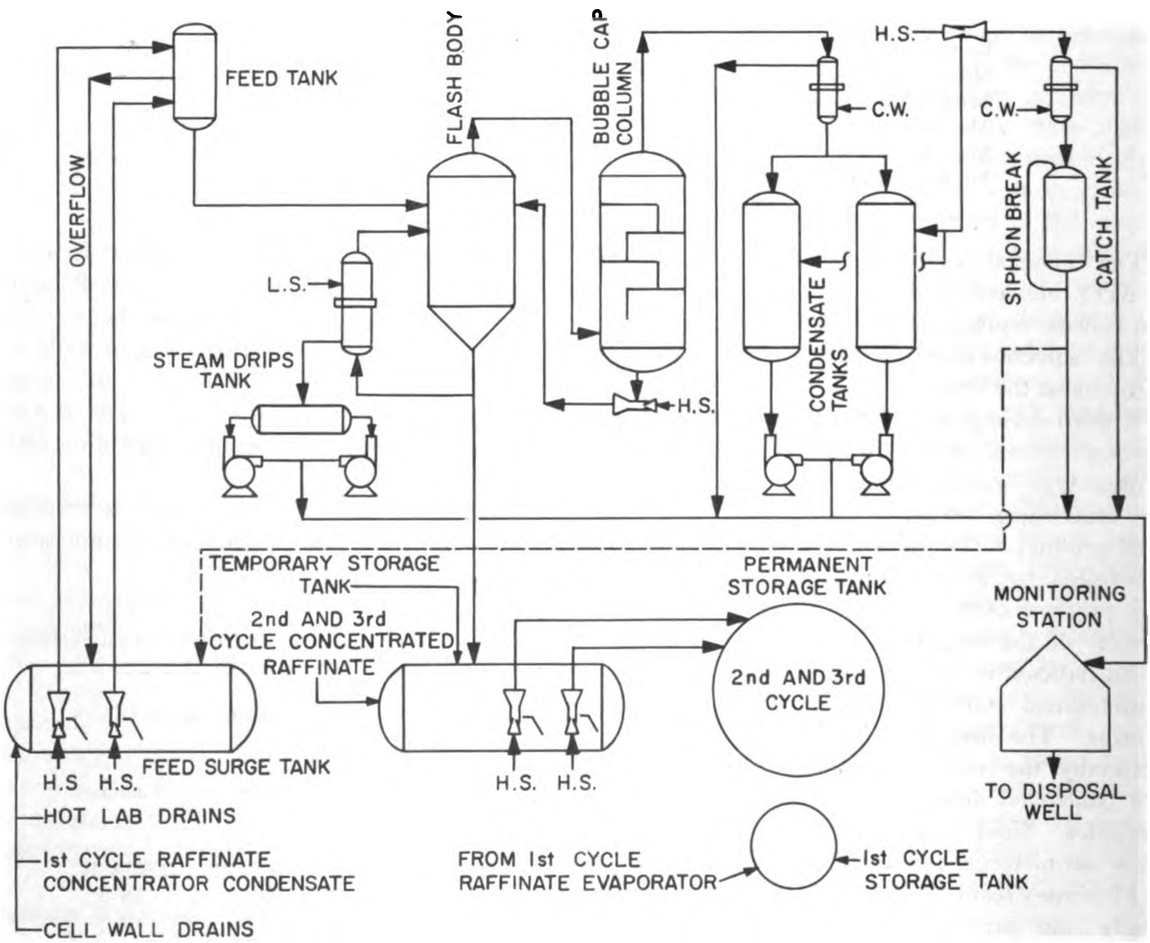


Fig. 5 Process equipment waste disposal.

The aqueous-waste stream from the first extraction column is collected in geometrically safe tanks and sampled to determine the uranium

tank to maintain a solution temperature of approximately 120°F in order to minimize corrosion.

Second- and third-cycle extraction raffinates are handled together in a manner similar to that for the first-cycle raffinate, i.e., sampled and concentrated in the Process Building and ultimately stored in a second 300,000-gal tank buried in the waste-tank farm. No reflux condensers or cooling coils are provided in the lower-activity-level second- and third-cycle waste system.

Two other classes of liquid waste, which are collected separately to facilitate treatment, are the relatively low activity-level process-equipment waste and cell-floor drain waste. The cell-floor drain wastes are collected for sampling in two 4000-gal stainless-steel tanks in two cells in the deepest part of the Process Building. Normally, the uranium content and activity level of cell-floor drain waste is low enough for direct discharge to the ground, but during cell decontaminations, this waste can be transferred to the chemical-waste-evaporator system for concentration.

The process-equipment wastes from laboratory hot sinks, the solvent-recovery evaporator, the condensers on raffinate evaporators, and other process equipment are collected in two 4000-gal stainless-steel tanks in the Process Building. This waste is pumped to the 18,000-gal stainless-steel feed tanks for the chemical-waste evaporator in the Waste Disposal Building.

The chemical-waste-evaporator system for relatively inactive liquid wastes consists of a gravity-feed tank, a flash pot heated by an external reboiler, a bubble-cap tower, one main condenser, and two condensate receivers. A steam-operated air ejector discharging into an aftercondenser provides the vacuum for operating at up to 23 in. Hg absolute pressure. The evaporator is semicontinuous, the water being evaporated continuously from the waste, and the concentrate accumulating in the flash pot for batchwise dumping. The waste circulates between the flash pot and the reboiler by natural convection, thus avoiding the use of a circulating pump. The condensate is sampled for radioactivity before being discharged to the disposal well and can be reprocessed if necessary. The concentrate is ultimately stored in the 300,000-gal tank used for second- and third-cycle raffinates. Over-all radioactivity decontamination factors of approximately 10^4 are realized, the decontamination factor being defined as the ratio of the activity in the feed to that in the condensate. During a typical MTR processing run, about 1×10^{-7} curie of activity are discharged to ground with the condensate for every curie of activity in the fuel elements. Activity discharged from the storage basin and the cell-floor drain systems bring the total activity discharge to about 7×10^{-7} curie for each curie of fuel-element activity.

Steam condensate, discharged cooling water, and waste from floor drains in nonradioactive areas of the plant mix with the evaporator condensate and other slightly radioactive wastes and flow to a monitoring station before being discharged to the disposal well. A continuous-activity monitor is employed to record instantaneous readings of the activity in the waste. A composite sample whose volume is proportional to the volume of waste discharged during its period of collection is taken regularly for laboratory checking of the continuous monitor. The waste is discharged into a ground-water stream of considerable volume, which travels underground for several hundred miles before emerging to the surface.

Gaseous wastes. Gaseous wastes from the process are discharged directly to the atmosphere through a 250-ft stack after filtration through fiberglass beds and dilution with the building ventilation air.

Solvent Recovery. The spent solvent from the solvent-extraction cycles is collected in geometrically safe collection vessels and sampled for uranium. If high in uranium, it may be recycled to the first-cycle stripping column. Normally the spent solvent is contacted with 0.5-molar sodium hydroxide at the ratio of 30 parts solvent to 1 part sodium hydroxide. The mixture of solvent and sodium hydroxide is fed continuously into a four-plate bubble-cap fractionating tower where the solvent is distilled to remove completely solvent decomposition products and fission-product contamination. The recovered solvent is reused in the process. The hexone–sodium hydroxide contacting vessels were originally provided with high-speed agitators. However, it has been found that agitation is not

necessary to produce a solvent product of satisfactory quality, and the agitators are no longer used.

The solvent recovery equipment is shown in Fig. 4.

Recovery of Uranium Salvage. Solutions from the process operations and laboratories high in uranium are collected in geometrically safe vessels, sampled for uranium (primarily for critical-mass control), and then evaporated to minimum volume in a batch evaporator. The concentrate is stored in another geometrically safe bank and then recycled to the process-feed preparation vessels. This equipment is also shown in Fig. 4.

PLANT FACILITIES

Design Philosophy. *Direct maintenance.* The Idaho Chemical Plant was designed for direct maintenance. The process equipment is designed with sufficient capacity to allow periodic shutdowns for maintenance operations. The equipment is of simple mechanical design for easy decontamination and repair and contains a minimum of moving parts. Solution addition funnels and outlets to the waste system are provided to facilitate decontamination with chemical solutions. Critical items, such as transfer jets, valves, and pumps, are installed in pairs, or alternate transfer routes are provided so that failure of one piece of equipment will not require a process shutdown for repair. Much of the equipment with a high maintenance potential, such as diaphragm-metering pumps and samplers, has been placed in lead-shielded cubicles located outside the hot cells. To minimize maintenance requirements during the processing of radioactive solutions, all equipment is leak-tested and operated on simulated process solutions before actual radioactive processing operations begin. Stainless-steel liners and spray nozzles are provided in the process

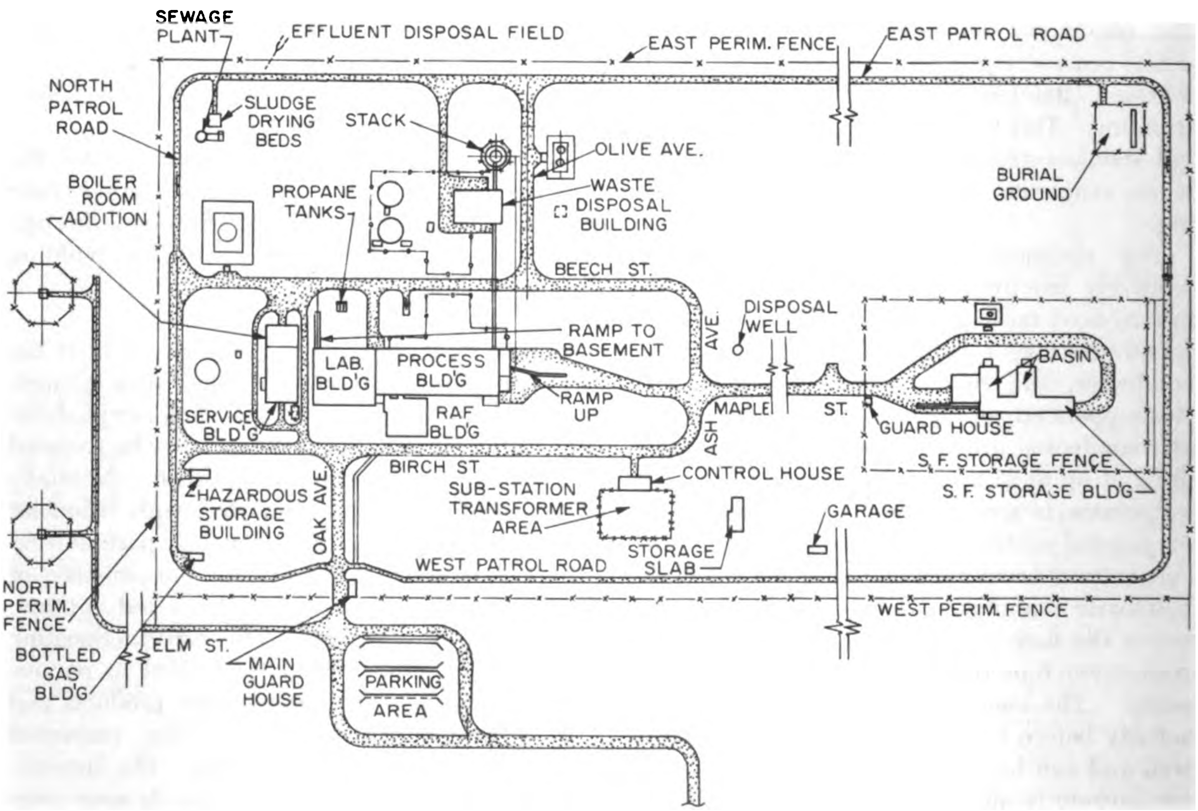


Fig. 6 Chemical Processing Plant.

cells to facilitate external decontamination of the equipment and the cells. The direct-maintenance philosophy allows a maximum amount of process equipment to be placed in each cell since no provision is made for removal by remote methods. Ladders and platforms are provided in many cells to allow maintenance personnel easy access to otherwise hard-to-reach equipment.

Shielding. The radioactive process and auxiliary equipment is shielded either by the cell walls or by unit shielding outside the cells. In general, the shielding is designed to reduce the radiation intensity to less than 1 mr/hr in the zones to which personnel normally have access when processing feed material.

Critical-mass control. As fissionable materials are processed, there is always a chance of accumulating a critical mass. The process and process equipment must of course be designed to prevent critical conditions. Each process vessel is made safe by one of the following methods:

1. Limited concentrations, in which the concentration of the solution is held within the range where a chain reaction is not possible because of neutron capture by hydrogen.
2. Mass limitation, where the quantity of fissionable material allowed in the vessel is kept below the critical amount under any possible condition.
3. Safe geometry, where the vessel diameter is such that critical conditions can never be achieved because of high neutron loss. Vessel spacing is such that interaction between vessels is minimized.

All vessels in the continuous-feed storage, extraction, waste, and product areas are of safe geometry. Vessels one step removed from the continuous equipment are mass- or concentration-limited, and critical conditions are prevented by rigid process control measures.

Arrangement. The plant is located on a restricted site approximately $\frac{3}{5}$ mile long by $\frac{1}{5}$ mile wide. Within this security area all fuel-storage, processing, waste-disposal, and service facilities are located as shown in Figs. 6 and 7. All processing facilities, the fuel storage basin, and active-waste storage tanks are underground, extending in the case of the Process Building to a point 55 ft below grade. All structures above grade contain no uranium-processing equipment and are constructed of steel framing with insulated Transite siding. Structures were designed for earthquake zone 2 conditions.

Main Process Building. The Process Building, which houses the bulk of the equipment and controls, is a rectangular structure, largely below ground level, and approximately 240 ft long by 100 ft wide by 90 ft high from subfloor level to the pitch of the roof. In one section the building is approximately 60 ft below ground level. The building encloses a usable floor area of 63,174 ft^2 and a usable volume of 991,851 ft^3. The outside volume is 1,420,212 ft^3. Approximately 400,000 ft^3 of the building, based on outside dimensions, consists of concrete walls for shielding and structural purposes. This is almost 30 per cent of the total outside volume.

Structurally, the building consists of two levels. One level is of reinforced concrete, the other of Transite and structural steel. Most process equipment containing radioactive materials is located within concrete walls. Chemical make-up tanks and auxiliaries are located in the Transite-steel section.

The concrete section is divided into two rows of cells with operating, service, and access corridors between the two. Outboard from the two cell rows are located the sampling corridors containing the sampling equipment. Directly beneath the sampling corridors are located the cell exhaust ventilation ducts, vessel off-gas, sampler off-gas, and dissolver off-gas lines.

At the south end of the cell rows are located the radioactive-waste collection tanks with their auxiliary pumps and pits. These tanks collect waste from process equipment and cell floor drains. This is the deepest part of the building, and the floor drain system is constructed for gravity flow from the cells to the tanks.

The cell floors and the walls, with heights ranging up to 45 ft 6 in., are lined with type 347 stainless steel. The walls of the cells adjacent to the operating corridor are honeycombed with offset pipe sleeves for entrance and exit into the service, control piping, and instrumentation cells. Normal access, when required by personnel, is through labyrinth corridors and doors located at the lowest level. Air flow into the cells

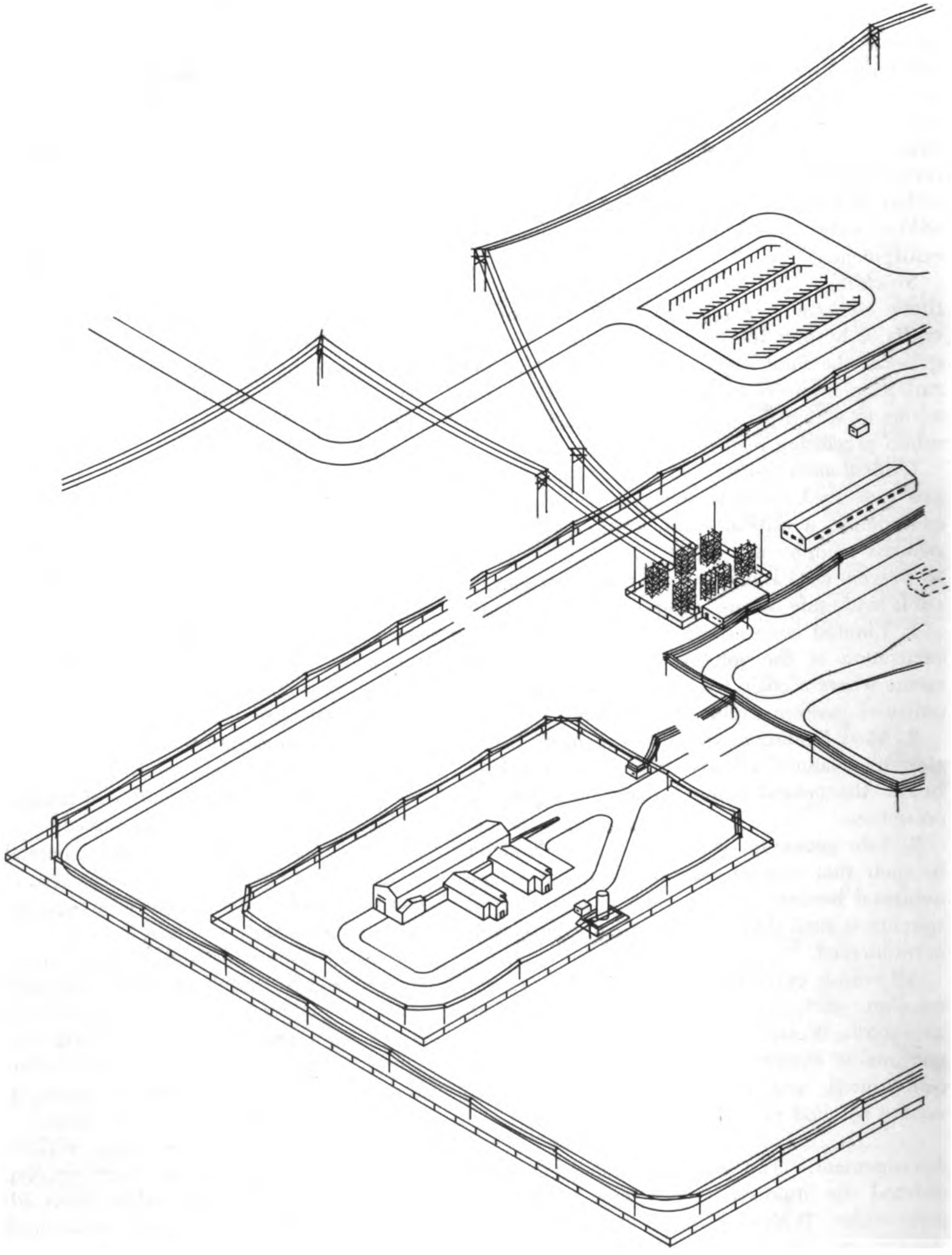
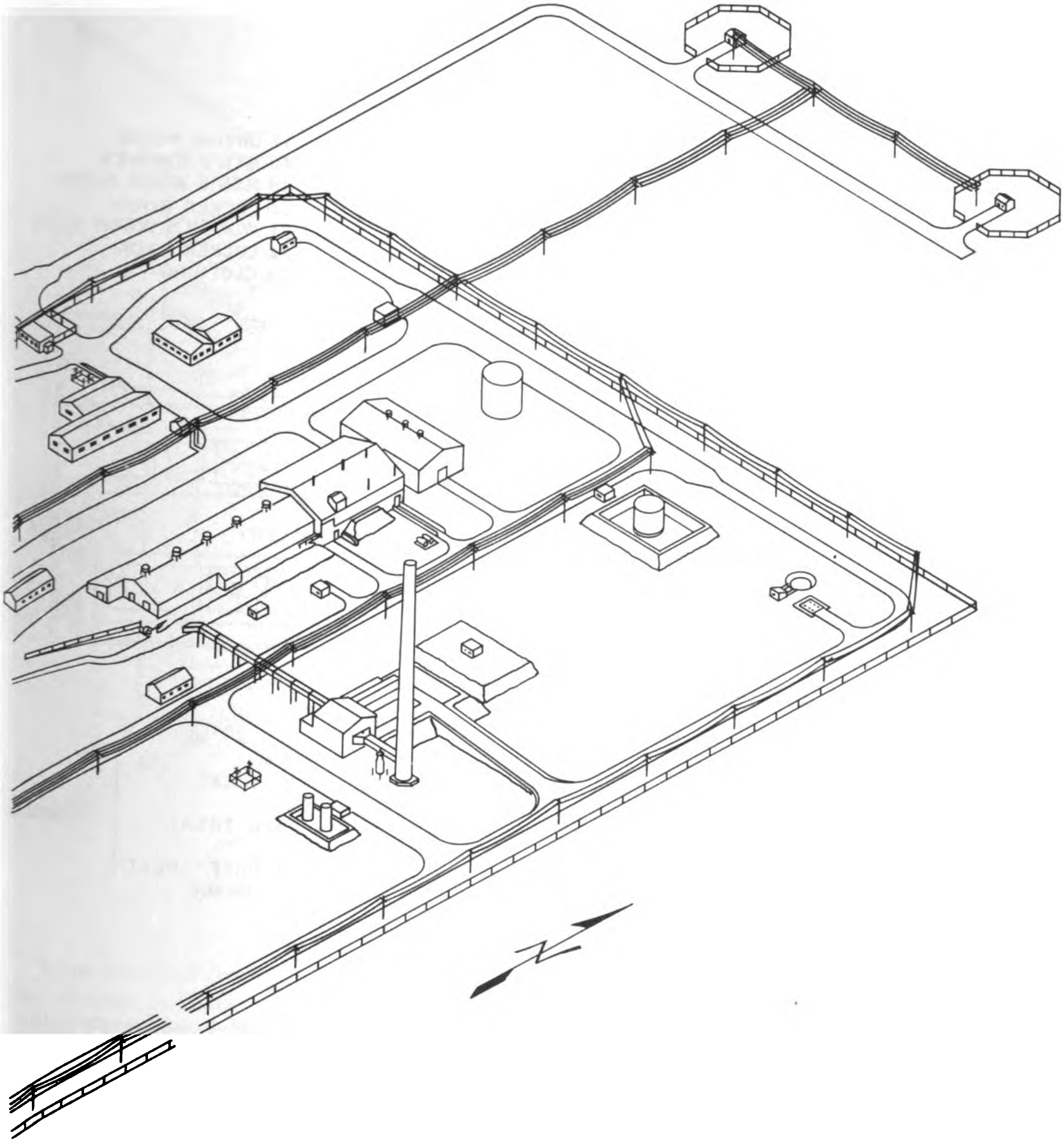


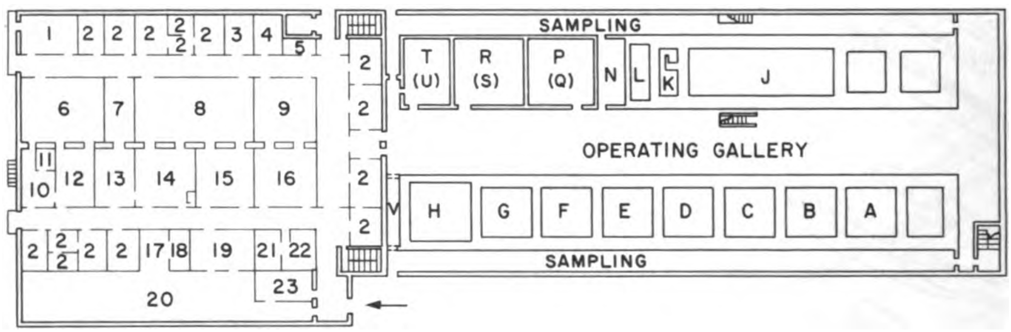
Fig. 7 Isometric view of



Chemical Processing Plant.

LABORATORY AND ADMINISTRATION

1 STOCK	9 SAMPLE DILUTION	17 DRYING ROOM
2 OFFICES	10 OPTICAL LAB.	18 MEN'S SHOWER
3 DISH WASH	11 DARK ROOM	19 MEN'S WASH ROOM
4 HEALTH PHYSICS	12 CHEM. SPEC. PREPARATION	20 LOCKER ROOM
5 EMERGENCY WASH	13 MASS-SPEC. PREPARATION	21 WOMEN'S WASH ROOM
6 INSTRUMENT LAB.	14 MASS SPECTROMETER	22 LOCKER ROOM
7 COUNTING ROOM	15 COLD LAB.	23 CLOTHING
8 WARM LAB	16 WARM MISCELLANEOUS	



PROCESS CANYON

A MTR MAKE-UP	H SOLV. RECOVERY	P SOLVENT PUMP ROOM
B MTR MAKE-UP	J MTR STORAGE	Q 1st CYCLE AQ. RAFF. TREAT.
C MTR MAKE-UP	K 1st CYCLE EXTRAC.	R DECONTAMINATION
D SPARE	L 2nd CYCLE EXTRAÇ.	S 1st CYCLE SOLV. RAFF. TREAT.
E SPARE	M UPPER PART OF "N"	T SAMPLE DILUTION
F SPARE	N 3rd CYCLE EXTRAC.	U 2nd AND 3rd CYCLE RAFF. TREAT.
G HOT SALVAGE		V 3rd CYCLE PROD. STORAGE

P–U: 2 LEVELS

Fig. 8 Process Building layout.

is through louvers in the doors, the access corridor serving as a large distribution duct in the building ventilation system. Access to equipment in the cells is through hatch openings in the roof, the covers of which are removable by an overhead crane installed for cells on the west side, and by a mobile A-frame crane for cells on the east side in the Transite-steel section of the building.

Process cell floors are so pitched that, in the event of a major spill, solution depth cannot exceed an "always-safe" depth. A geometrically safe sump with automatic jet and alarm is placed at the low point in each cell.

There are no direct connections between process tanks containing uranium and waste collection drains. All floor drains are normally closed by an air-operated valve to prevent accumulation of uranium in the waste system and to force solution toward the criticality sumps.

The right-hand section of Fig. 8 shows a floor plan of the Process Building at the operating-gallery level. Figure 9 shows a section through the building.

A double row of instrument panels arranged back to back is located in the center of the operating gallery (Fig. 10) to serve both cell banks. Service lines for water, steam, air, and condensate enter the cells at the operating-gallery level.

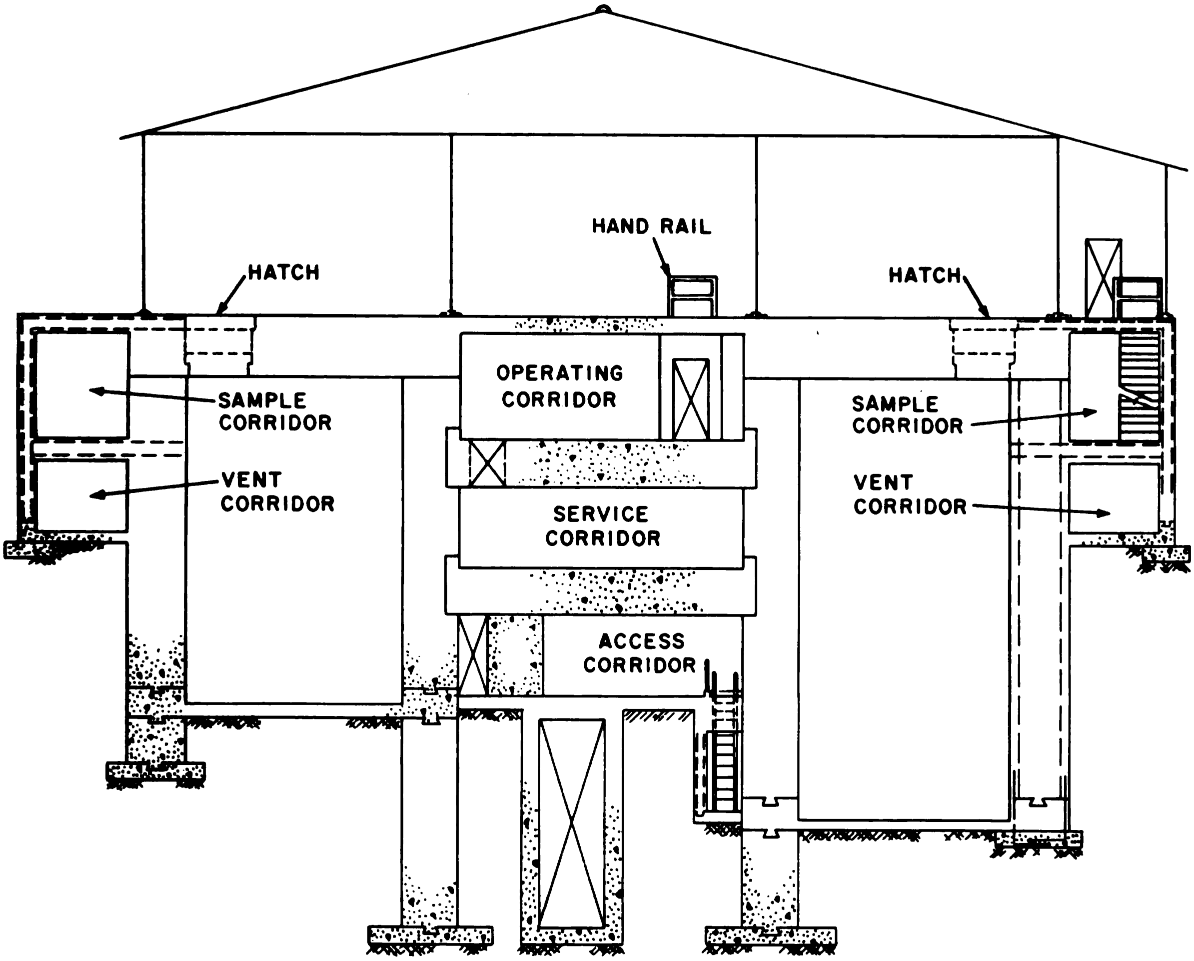


Fig. 9 Section through Process Building.

A hot analytical facility (Cell T) is located in the Process Building. This area is used primarily for storage and analysis of high-radioactivity-level samples for the dilution of samples before transporting them to the laboratory, and for decontamination equipment for preparation of the samples.

Laboratory facilities and administrative area. The Laboratory and Administration Building immediately adjoins the Process Building on the north. This building houses the administrative offices, cafeteria, health-physics service, telephone exchange, first-aid facilities, low-radiation-level analytical laboratories, process development laboratories, and a small machine shop. The analytical laboratory floor is located on the same level as the process operating gallery and sampling galleries. A floor plan of the laboratory area is shown in the left-hand portion of Fig. 8, which also lists the functions of the various laboratory areas.

The product packaging and storage areas, maintenance shop, parts-storage area, and development laboratory are located at a level below the analytical area.

The area directly above the analytical laboratory contains hood exhaust fans, filter, water stills, and other service equipment. The levels directly above the offices shown on the analytical-laboratory level contain the first-aid station, cafeteria, and administrative offices.

Source of fissionable-material storage canal. Incoming irradiated reactor fuels are stored in an underwater storage basin and transfer canal

located approximately ⅓ mile south of the Process Building.

Fuel is transferred from the reactors in lead casks and unloaded under water in one of two transfer basins. Fuel elements are stored in stainless-steel buckets suspended from a system of overhead tracks. The buckets are arranged in a 2-ft center-to-center array in two water-filled basins opening off a main transfer canal. Provision for the possible installation of a third storage basin has been made. A plan view of the building is shown in Fig. 11. The unloading pit, canal, and storage basins are so constructed as to provide a minimum of 15 ft of water cover at all times when radioactive material is handled outside the carriers.

The basin water is continually recirculated through a filter to keep it clear. Fresh water is continually added to the basin at rates of 10,000 to 25,000 gal per day and overflows a weir to a manhole discharging to the ground. Chlorine is added to the water to a concentration of 0.2 ppm to prevent the growth of algae, and sodium nitrate is added to a concentration of 200 ppm to inhibit corrosion of the aluminum-clad fuel elements.

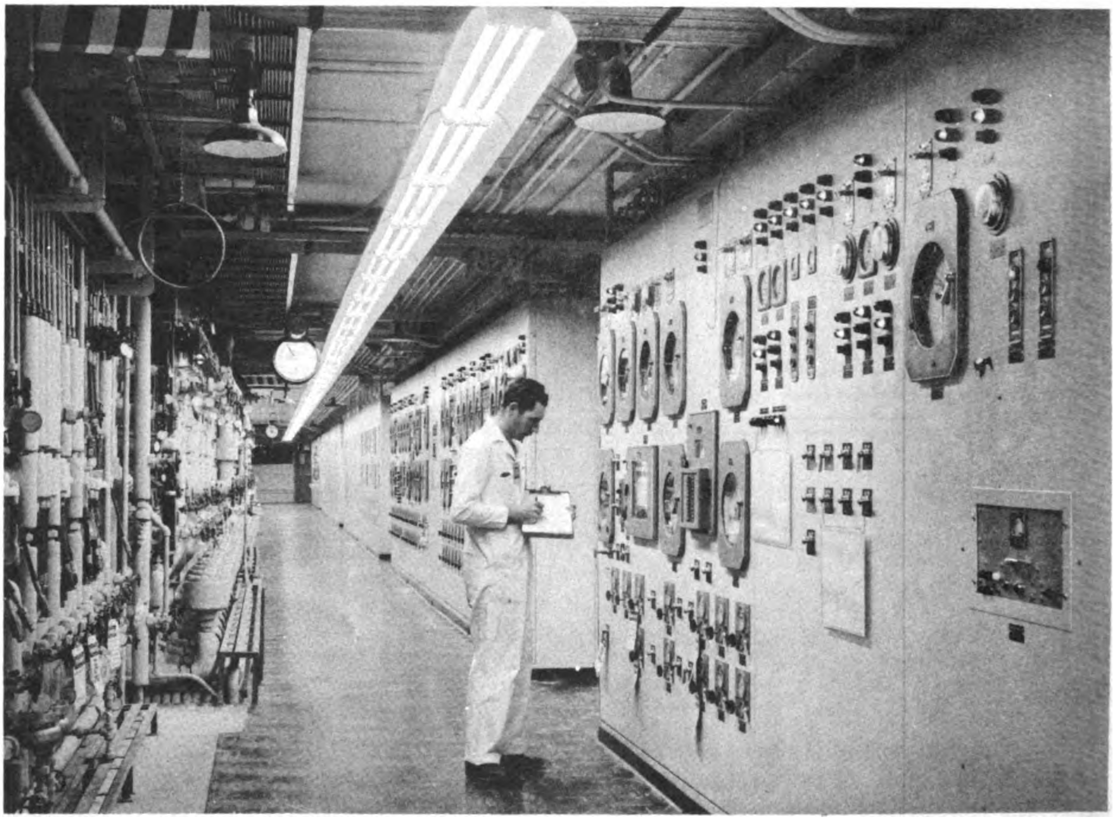


Fig. 10 Operating gallery in Process Building.

The Fuel Storage Building contains sufficient equipment to make it an almost self-contained unit within the general area of the chemical plant. A separate heating and ventilating system is included, with oil storage tank and air cleaning system. An auxiliary generator is installed for emergency power supply. Water is obtained from the main plant source but is metered and filtered for the Storage Building by separate equipment. Basin water recirculation pumps are housed within the building.

The building is of structural steel covered with

Transite and is constructed over concrete basins and pits; floor gratings are located over the basins and canals except for slotted passageways to allow for passage of bucket rods. The gratings clear the maximum level of water by a minimum distance of 1 ft.

Waste Disposal Building and Waste Tank Farm. The Waste Disposal Building houses both liquid- and gaseous-waste disposal equipment. It is essentially three units integrated into one building, each unit being a separate and distinct part of the radioactive-waste handling facilities of the plant. The three main units are:

1. Three waste storage tank cells on the north side, which contain five 18,400-gal usable-volume tanks for temporary storage of extraction-column wastes and general plant waste. Only one tank serves the liquid-waste evaporator directly.
2. Two cells located on the east side, which contain the liquid-waste evaporator and its auxiliary tanks.
3. The exhaust fans for process-cell ventilation, which are located in a wing at the southeast end of the main section, and the process-vessel ventilation equipment, consisting of a filter bank and two high-speed exhausters, the former being located in a cell on the west side and the latter being located in a cell at the extreme southwest end of the main section.

A plan view of the Waste Disposal Building is shown in Fig. 12.

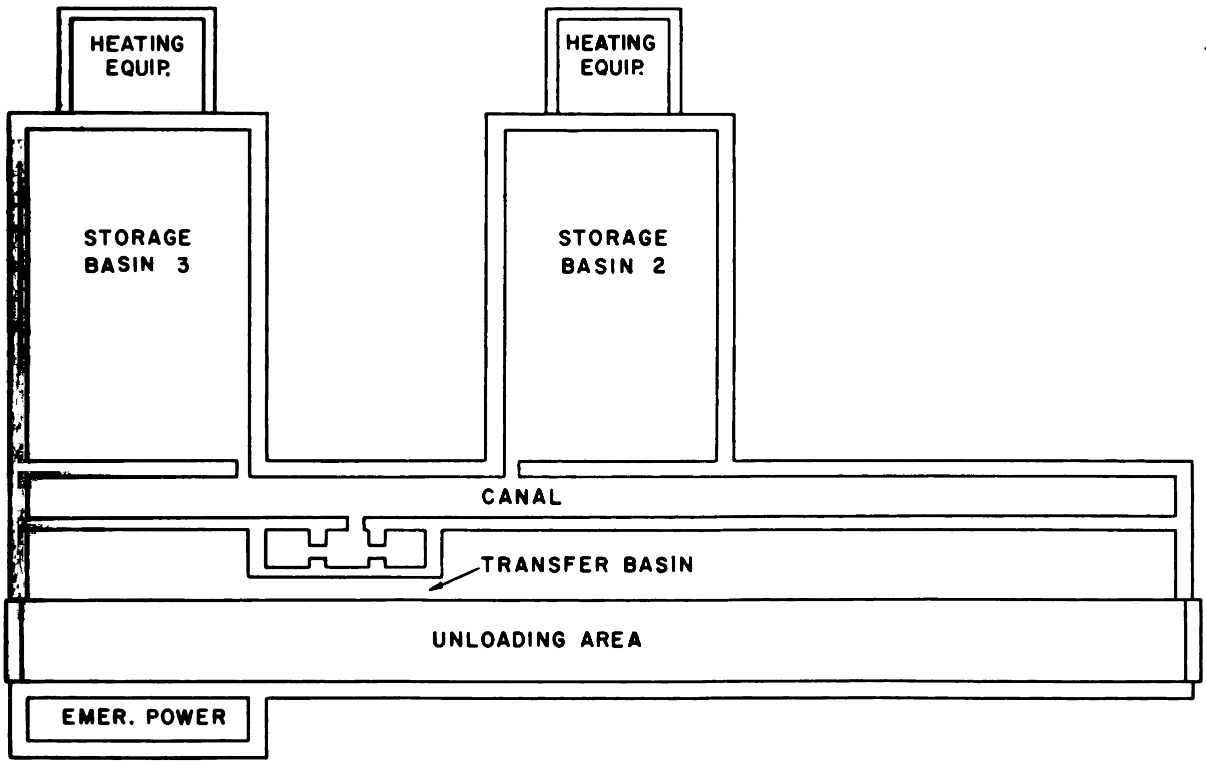


Fig. 11 Fuel Storage Building.

The cells are all beneath grade level and consist of heavy reinforced-concrete walls and roof. The tops of the cells are above ground level. These structures house the ventilation fans and a liquid air plant that supplies all nitrogen and oxygen required at the National Reactor Testing Station.

The usable volume of the Waste Disposal Building is 294,671 ft^3, with an inside floor area of 15,687 ft^2.

Ventilation air and process off-gases from the Waste Disposal Building are discharged through a 250-ft stack at the east of the building.

The Waste Tank Farm is located north of the Waste Disposal Building and consists of two

300,000-gal type 347 stainless-steel tanks for the storage of radioactive wastes. The tanks are enclosed in concrete vaults buried under 10 ft of earth. One tank is provided with internal cooling coils and reflux condensers and is used for storage of first-cycle waste. All other concentrated wastes are stored in the second tank, which has no provision for cooling. A large empty area for future tanks has been left next to these tanks.

out any solvent vapors that might accumulate and cause an explosion hazard.

Fresh air under a positive pressure is supplied to the Process Building, after being washed to reduce dust loading and heated in the Service Building. This air is distributed to the nonradioactive areas of the building and drawn into the cells and sampling corridors. The main air flow to the cells is through louvered doors in the

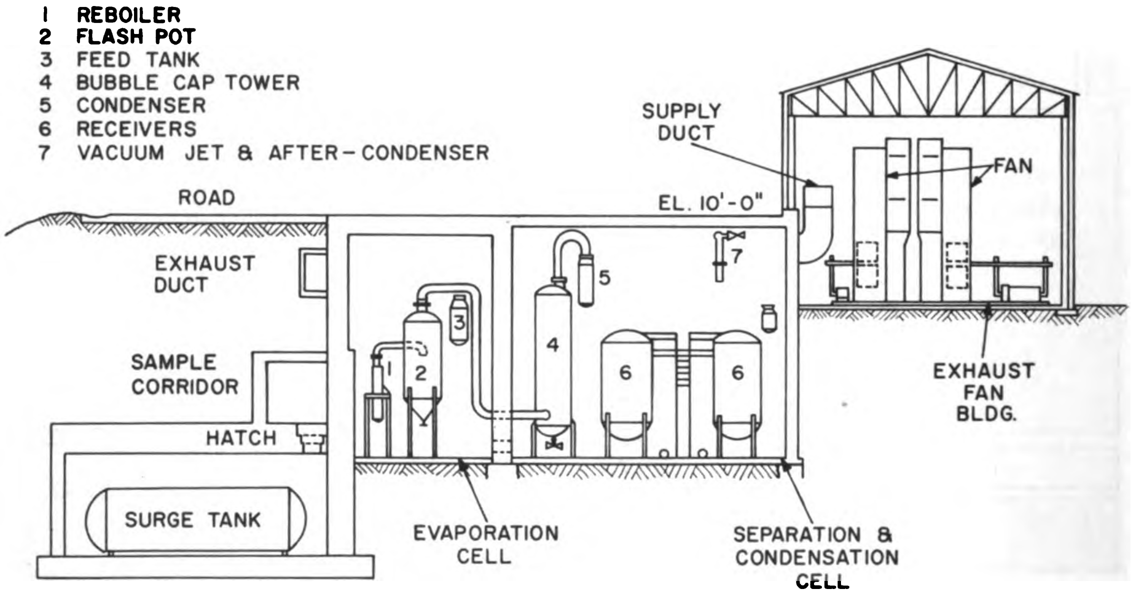


Fig. 12 Section through Waste Disposal Building.

Service Building. The Service Building is connected to the north side of the Laboratory and Administration Building. This building houses the steam plant, electrical equipment, and heating and ventilating equipment for the Process and Laboratory and Administration Buildings, emergency electric power unit, pumps for the fire-protection system, and equipment for the compressed-air system. The Service Building is constructed of structural steel with Transite siding and has a usable floor area of 9482 ft^2 and an over-all volume of 248,840 ft^3.

Ventilation System. All process areas are kept under a negative pressure of about 0.2 in. H_2O with respect to the personnel areas in order to prevent the spread of radioactive contamination. The ventilation system is designed to provide 20 air changes per hour to the process cells to sweep

access corridor. The air is exhausted from the cells and sample corridors through the vent tunnels and delivered to the stack through a connecting duct and two 75-hp fans in the Waste Disposal Building. The exhaust air is not cleaned before discharge through the stack since all process equipment operates under a vacuum, making contamination of the cell air very unlikely.

The Waste Disposal Building cells are ventilated by a similar system.

Vessel Vent System. *Vessel off-gas.* The process vessel off-gas system is a low-volume system that is used to vent all radioactive processing equipment except for the dissolving vessels. The system is designed to keep the vessels under a negative pressure of about 1 in. H_2O with respect to the cells.

Vessels containing product solution are con-

nected through a vessel off-gas subheader and packed knockdown tower to the main vessel off-gas header in the vent corridor. Other vessels are vented directly into the header. The main header leaves the building at the southeast corner. A condenser is located at this point to remove steam vapors that enter the system during steaming of the process vessels for decontamination. The gases are transferred to the Waste Disposal Building through an underground line. The gases are filtered through a packed-bed fiberglass filter for the removal of radioactive particles before they pass through the exhaust blowers to the stack.

Sampler off-gas. The off-gas system serving the sampler stations is similar to the vessel off-gas system. A minimum air velocity of 100 lin ft/min is maintained through any opening in the sampler stations to prevent the spread of radioactivity.

Dissolver off-gas. The dissolver off-gas system is designed to provide a pressure differential of up to 10 in. H_2O between the dissolvers and the cells during fuel-element dissolutions. Vacuum is drawn on the system by a steam-jet ejector.

Each dissolver is equipped with a reflux condenser and entrainment separator. The dissolver off-gases pass through this equipment into the stainless-steel dissolver off-gas line in the vent corridor. The off-gas line passes underground to the Waste Disposal Building, where it is filtered before discharge through the jet to the stack. Dissolvers may be closed off from the off-gas system and vented through the vessel vent system during periods of inoperation.

PROCESS EQUIPMENT

The Process Building process-equipment flow sheet is shown in Fig. 4, and the general methods of equipment operations were discussed under the heading Process. This section gives a description of the physical features of the equipment used for handling radioactive solutions.

Process Vessels. The process vessels are fabricated of type 347, 304ELC, or 309SCb stainless steel, as this material is highly resistant to corrosion by the nitrate ion contained in the process solutions and does not require annealing after welding. In general, type 309SCb is used only

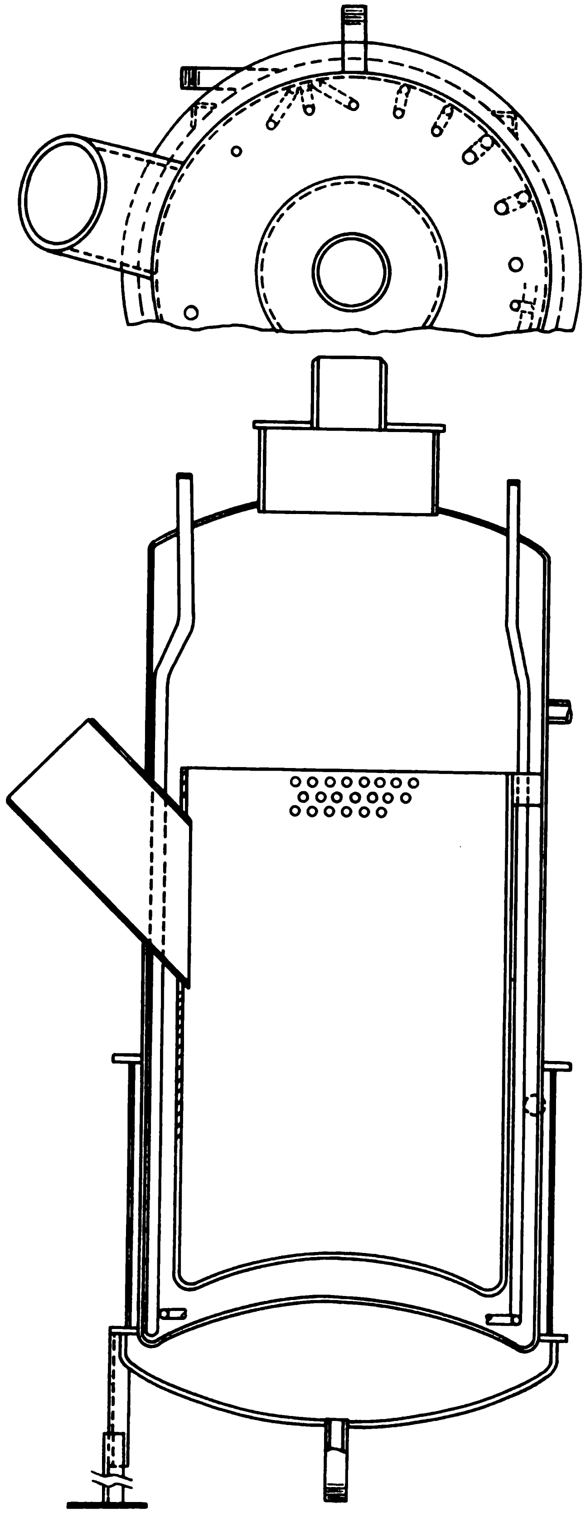


Fig. 13 MTR element dissolver.

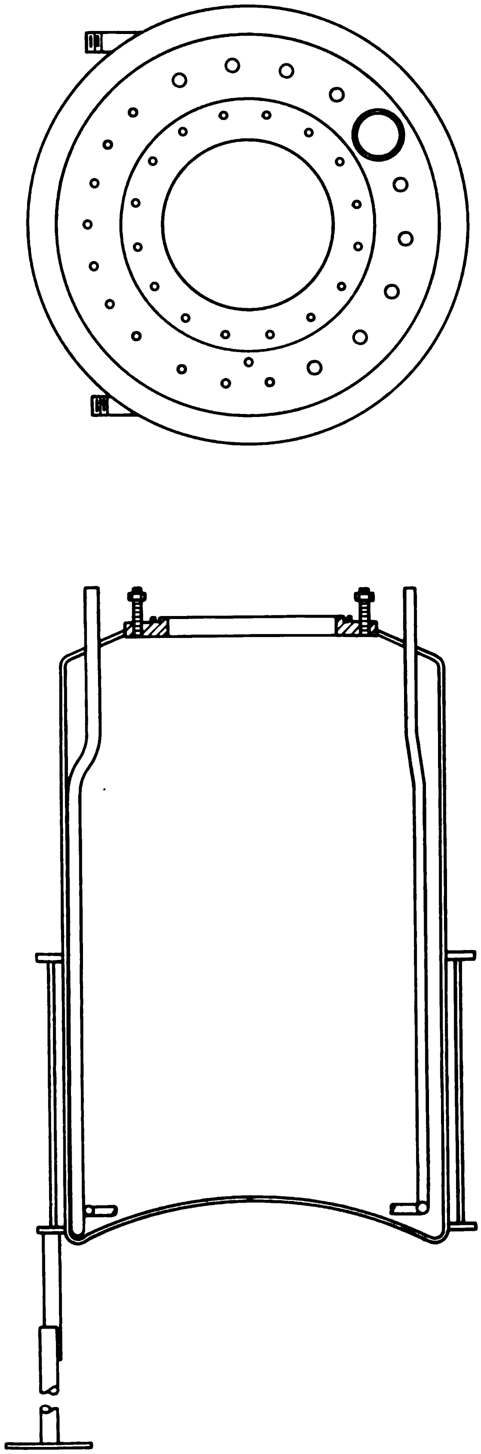


Fig. 14 Batch process vessel.

for dissolver vessels, which are subject to operation at boiling temperatures. Other high-temperature equipment is made of type 347. These construction materials have proved highly satisfactory and there have been no corrosion failures in the plant.

All vessels are of standard all-welded construction and were built by commercial fabricators.

Details of an MTR element dissolver are shown in Fig. 13. A chute for dropping the elements enters the vessel at the side and delivers the elements into the dissolver basket. The chute is normally closed with a standard blind flange except during element charging operations. The vessel is agitated with an air sparger ring when desired. A water and steam jacket on the lower one-third of the dissolver provides for heating and cooling. Solution transfer and addition lines and instrument lines enter at the top of the vessel.

Figure 14 gives details of a typical batch process vessel. This figure shows a feed-adjustment vessel used for adjusting the dissolver solution to feed specifications. The vessel has both an air sparger and a mechanical agitator for agitation.

Vessels that are emptied by jet suction usually are fabricated with a reverse-dish head on the bottom so that they may be almost completely emptied by a suction line located at the low point of the head. Some vessels emptied by bottom outlets do not have reversed heads. All vessels requiring agitation are equipped with air spargers, and a few also have mechanical agitators. Vessels requiring heating and cooling have external steam and water jackets; no internal coils are provided.

Vessels originally installed in the plant did not have internal spray nozzles. It has been found desirable to provide spray nozzles in all new vessels to allow spraying of decontaminating solutions against the upper areas of the vessels. Several spare nozzles are provided on most vessels for use if needed.

Condensers are of conventional construction, containing tube bundles with cooling water admitted to the outside of the tubes.

A typical solvent-extraction column is shown in Fig. 15. The columns are fabricated from

standard-sized pipe and are packed with stainless-steel Raschig rings. Aqueous outflow from the column is controlled by air pressure applied to the column jackleg. The diameters of the columns are small enough so that they are geometrically safe with respect to nuclear chain reactions. Packed heights and other details of the columns were given in Table 1.

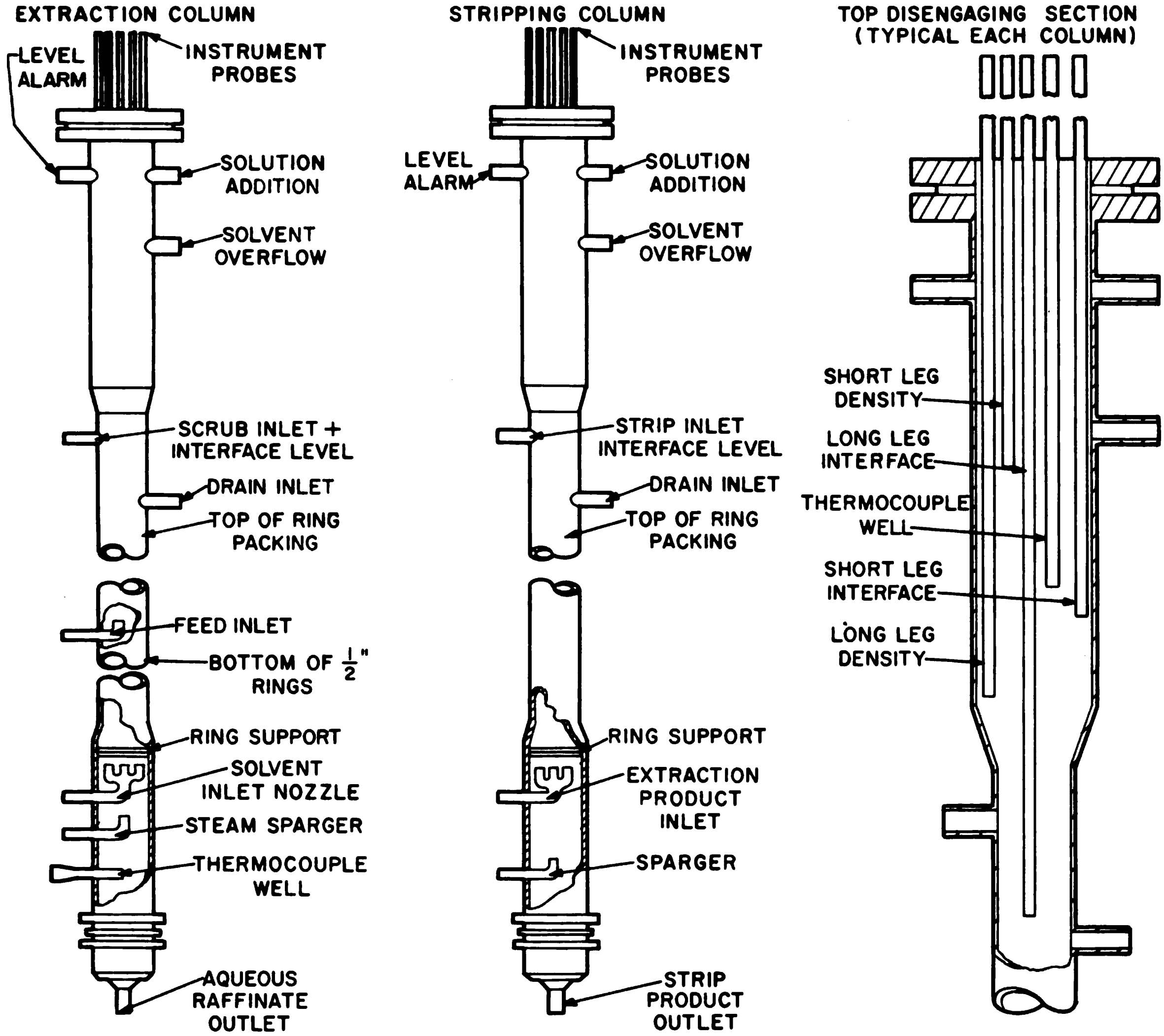


Fig. 15 Solvent-extraction and stripping columns.

A geometrically safe continuous evaporator is shown in Fig. 16. The steam jacket on the evaporator tube bundle is separated from the tube sheets at the ends of the bundle so that leakage from the tube sheets will fall to the floor rather than enter the steam chest. The vapor head is not geometrically safe, so an overflow line has been provided below the head for solution to overflow if the evaporator is overfilled. The overflow solution is collected in an auxiliary geometrically safe tank which empties back to the process for recovery of the overflow solution. The overflow line is pitched so that condensing vapors are returned to the evaporator. This type of evaporator is used for concentrating the intercycle feed and final product streams.

Piping and Valves. Process lines are type 347 stainless-steel tubing or schedule 40 pipe. Ventilation lines are of type 347, and instrument

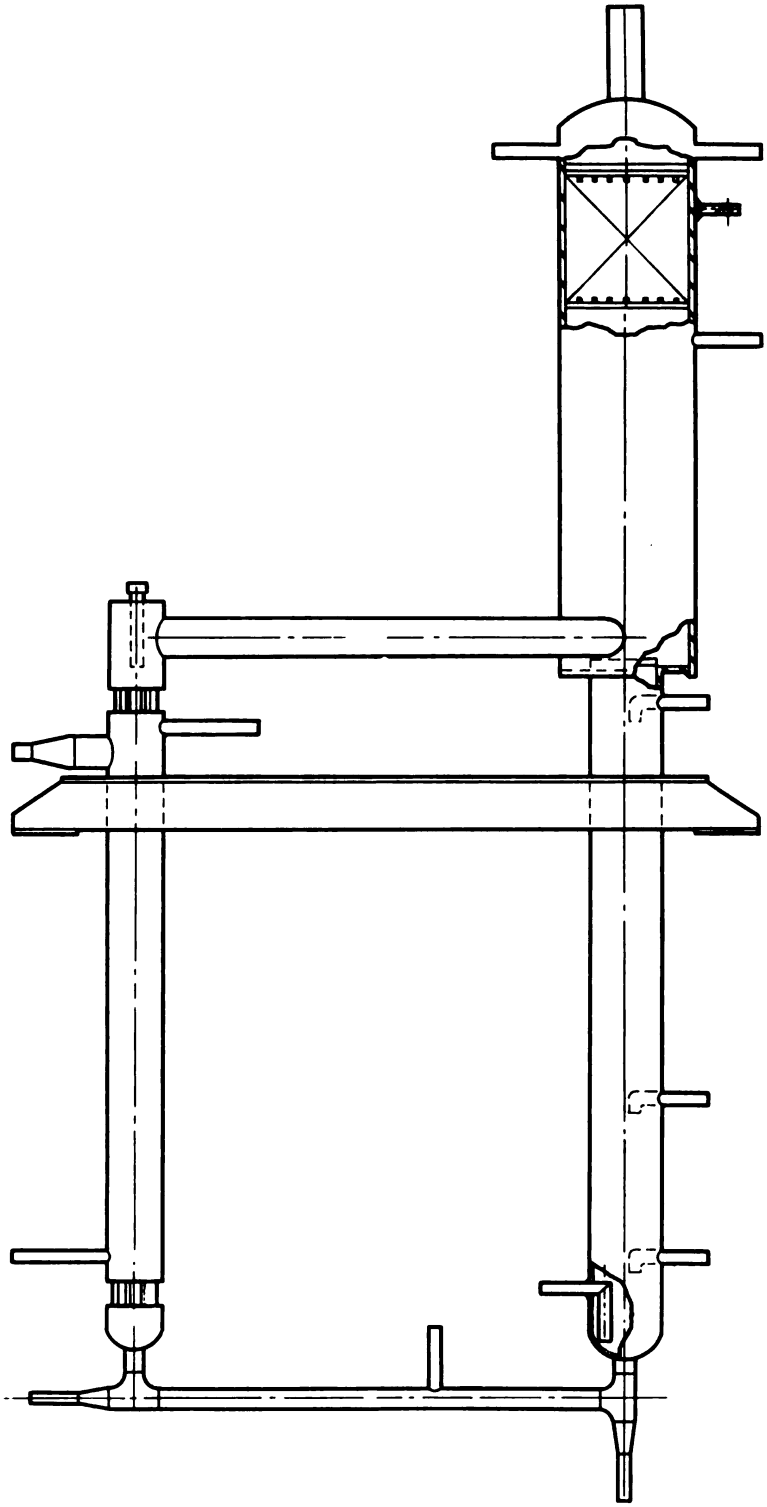


Fig. 16 Continuous evaporator.

tubing is either type 347 or 304 stainless steel. In some cases 309SCb stainless steel is used for dip tubes normally in contact with nitric acid solutions at high temperatures. Remotely controlled valves in the process areas are of type 347 stainless steel.

Lines and valves are sloped to drain by gravity when possible. The valves must be installed at a 45° angle with the horizontal plane in order to ensure good drainage.

All lines of less than 1 in. diameter in the original installation were of tubing and connected by nongasketed tubing connectors. Lines of 1 in. diameter or larger were of schedule 40 pipe connected by welding. The welded lines have served satisfactorily, whereas the tubing connectors have shown a tendency to leak, as evidenced by a high degree of external contamination in the cells. Much of the original tubing has been replaced with all-welded pipe, and all new piping is of all-welded construction.

A minimum number of valves are installed in the process areas. These are all double-bellows sealed valves operated by air pressure. The air-pressure controls are located on the operating-corridor panel boards. They are of the on-off type; no flow-control valves are used, with two exceptions. Air-operated-diaphragm flow-control valves are used to control the outflow rate of the third-cycle-product evaporator and the feed rate to the liquid-waste evaporator. These valves are located in relatively low-radiation-level zones. In critical locations, two valves are usually installed in parallel so that failure of one will not cause a process shutdown. Where prevention of valve leakage is critical, two valves are installed in series. Some of these extra valves were not provided in the original installation but were added at later dates.

The remote valves have given satisfactory service in most cases, although a few valves have either leaked excessively or failed in the shut position. One of the two bellows seals has failed in several cases, but two bellows on a single valve have never failed. Valve failures have never caused a process shutdown because of the installed-spare philosophy.

Mechanical Equipment. *Pumps.* Pulsafeeder pumps with two diaphragm heads connected by a liquid piston line filled with kerosene are used for feeding radioactive streams to the extraction columns and solvent recovery still. The drive mechanism and one head of these pumps are located outside of the process cells. The remote heads, which are the only part of the pumps handling radioactive solution, are located within the cells or in shielded areas just outside the cells. Two pumps are installed in the same service so that failure of one pump does not require a process shutdown during repairs. A remote-head pump is shown in Fig. 17.

The only difficulties experienced with these pumps are air-locking in the kerosene line and

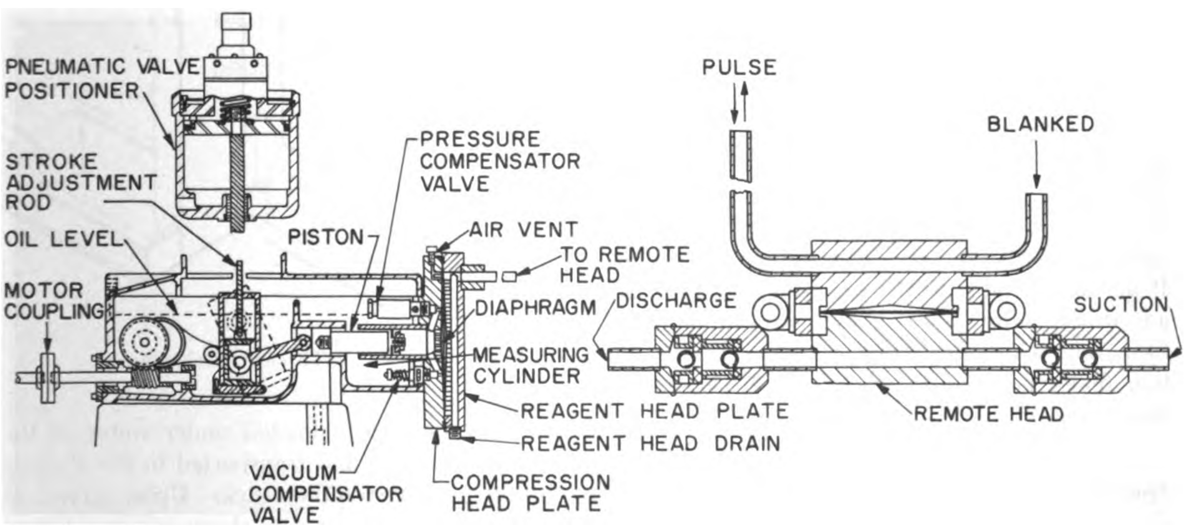


Fig. 17 Remote-head pulsafeeder pump.

plugging of the check valves. Kerosene-line air-locking can be minimized by installing lines of at least ½ in. diameter and installing the lines in such a way that sharp bends and level spots are not present. Plugging of check valves occurs infrequently and is easily remedied by steaming out the head through permanent auxiliary lines installed for this purpose from the service areas.

Agitators. Mechanical agitators are installed on some of the feed preparation vessels, on the hexone–sodium hydroxide mixing pots that feed the solvent still, and on the process-equipment waste and cell-floor drain waste collection tanks. Most of the agitators were originally installed with water-cooled mechanical seals. Some of these failed and were replaced by graphite-impregnated lead packing rings. These rings operate satisfactorily but allow some leakage of radioactive vapor. It has since been found that the agitators on the feed-preparation vessels are not necessary, as air sparging through the existing spargers provides adequate agitation. It has also been found that the hexone–sodium hydroxide mixing pots, which have no spargers, do not require agitation. The mechanical agitators on these vessels are no longer used. The mechanical agitators are still used on the waste collection tanks because they provide somewhat better agitation than spargers owing to the horizontal shape of these tanks.

Steam jets. Almost all solution transfers in the plant are made with steam jets. This method of transfer is easily adapted to remote control and is essentially trouble-free.

The steam lines supplying the jets are all vented into a common header through ¼-in. gate valves with a ⅟₁₆-in. hole drilled through the gate. The operator closes the vent valve before turning on steam to the jet and opens it again immediately after turning off the steam. If he fails to open it, there is sufficient air leakage through the ⅟₁₆-in. hole to prevent vacuum formation when the steam condenses, a condition that would cause solution to back up the steam line.

Special Equipment. *Fuel element chargers.* Fuel element chargers are shielded carriers used to transport the elements from the Storage Building to the Process Building. The chargers are usually designed to handle only one type of fuel element, but all chargers are of similar design, differing only in their dimensions.

The MTR element charger is a 2-ft 8-in.-diameter lead-filled cylinder of type 304 stainless steel. A 7-in. square well 28 in. deep, is provided to carry four elements. A lead-filled plug fits into the top opening and is secured in place by a locking bar. This charger is shown in Fig. 18. The charger is loaded under water at the Storage Building and transported to the Process Building by a straddle truck. Upon arrival at the Process Building, the charger is positioned over the dissolver chute and the screw-operated

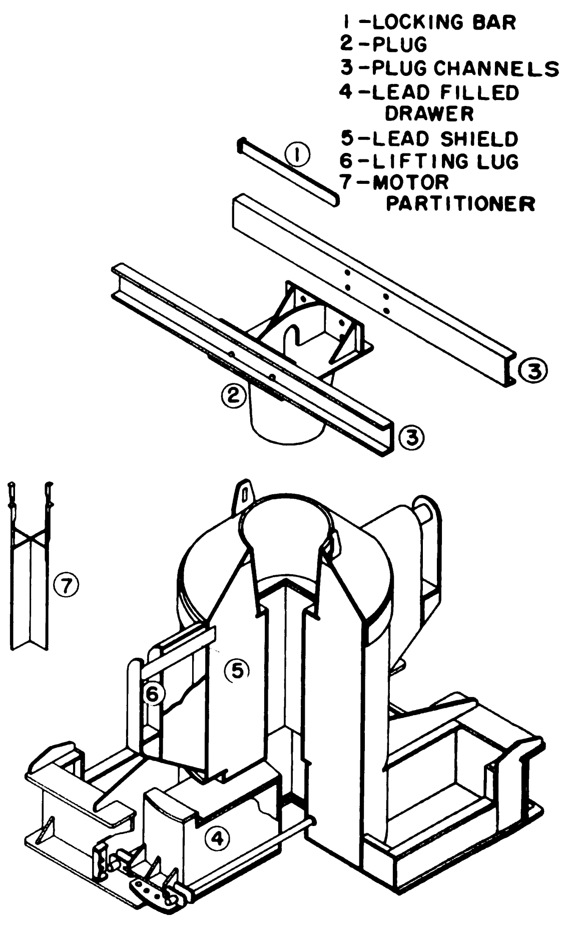


Fig. 18 MTR element charger.

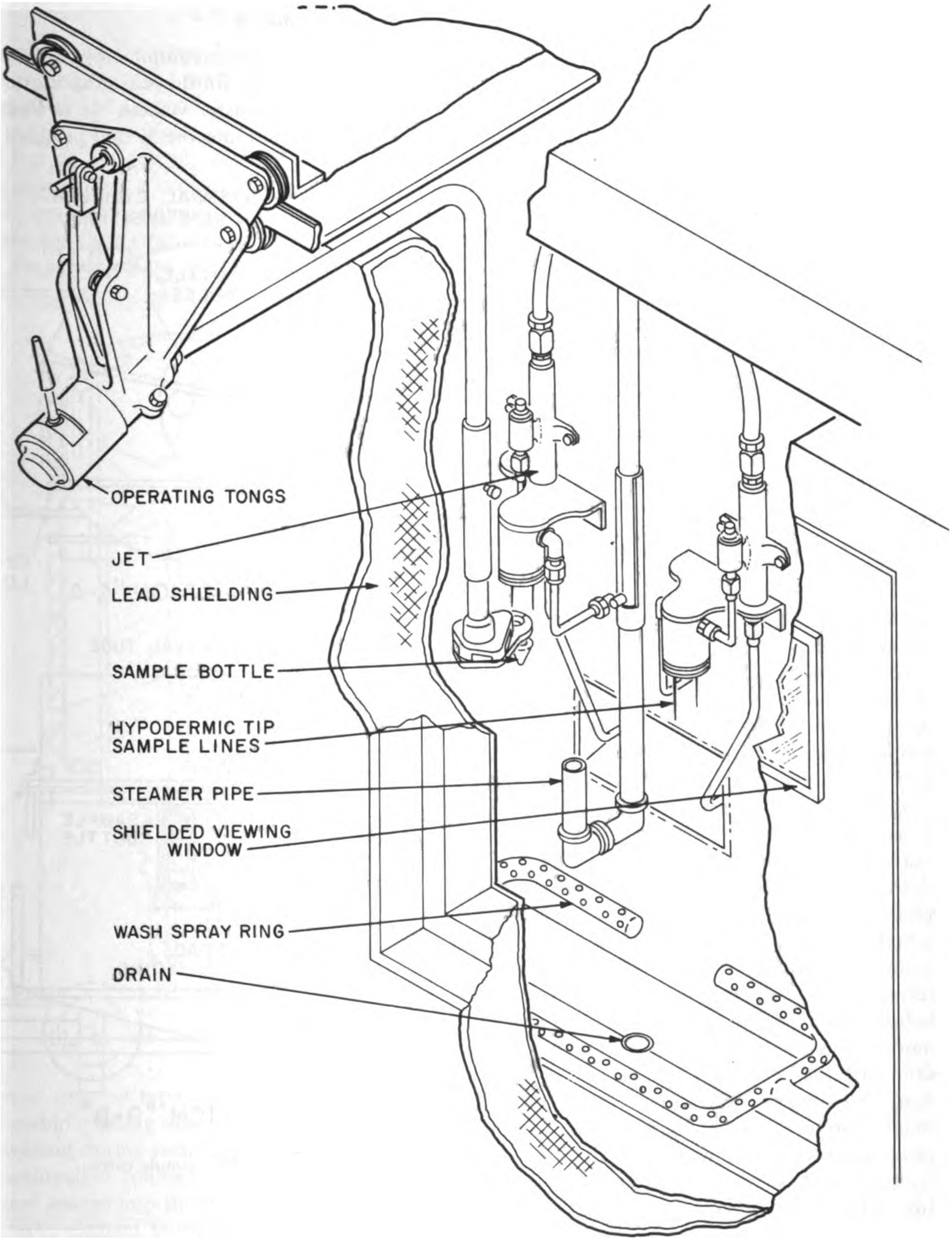


Fig. 19 Sample transfer station.

drawer is moved back, allowing the elements to drop into the chute.

The gross weight of the charger is 16,500 lb, and a minimum of 10 in. of lead shielding is provided around the elements. Lifting lugs on the side and a step arrangement on the base allow handling with the Process Building overhead crane or charger carrier.

Samplers. Samples of the radioactive process solutions are necessary for process control purposes. They are required also for accurate accounting of the fissionable material in the process.

A sampler system somewhat different from that used at other AEC sites was designed to meet the particular needs of the plant. As can be seen in the building sectional view in Fig. 9, special sampling corridors were constructed at operating-corridor level for each cell bank. Samplers for several cells were grouped so that a continuous 4.5-in. lead shield having one entry for a sample carrier and a single set of sample handling tongs could be used. Figure 19 shows a single air-operated sampling jet, tongs, and shield. The sampler's tip is fitted with two hypodermic needles that punch through the neoprene cap on the sample bottle. The sample bottles are removed from the sample carrier (Fig. 20), conveyed to the sample jet, and raised to sampling position. The sample is drawn by drawing a vacuum on the bottle through the short needle with the jet, which in turn draws process solution from the vessel through the sampling line and long needle into the bottle. Solution is circulated through the bottle and returned to the process vessel for a few minutes before the jet is turned off and the bottle removed. Air-bleed orifices are provided in sampler intake lines that have a fluid lift greater than 17 ft to provide an air-lift effect and thus reduce the jet vacuum requirements. The sampling operation is viewed through a lead-glass window located directly in front of the sampler tip. The filled sample bottle is returned to the sample carrier and removed from the sampling station for delivery to the analytical facilities. The sampler stations are equipped with steamers that are used to steam the intake and discharge lines after samples are taken; they are also used during sampler decontamination operations.

Product handling equipment. The product solution from the third-cycle evaporator is collected in two transfer vessels. It is then transferred in batches into the V Cell product collec-

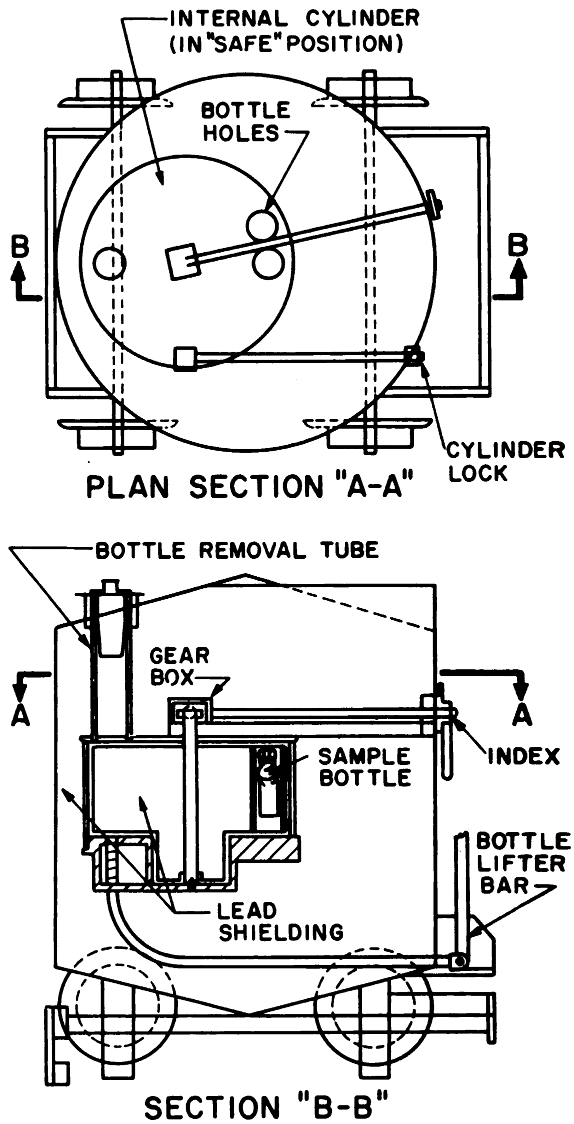


Fig. 20 Sample carrier.

tion vessels by applying air pressure to the transfer vessels. The product is drawn by vacuum from the V Cell vessels into either of two product bottle-filling burettes. The product is drained from the burettes to the always-safe product bottles by gravity. The product bottle

is sampled and then weighed on a balance accurate to the nearest 1 g of weight. The bottle is then placed in a second container ("birdcage") with outside dimensions (2 by 2 ft) that minimize, but do not entirely eliminate, the possibility of assembling a critical mass. The product is then ready for shipment.

Filter handling equipment. The filter element used for clarification of the feed solution is shown in Fig. 21. The star-shaped element is

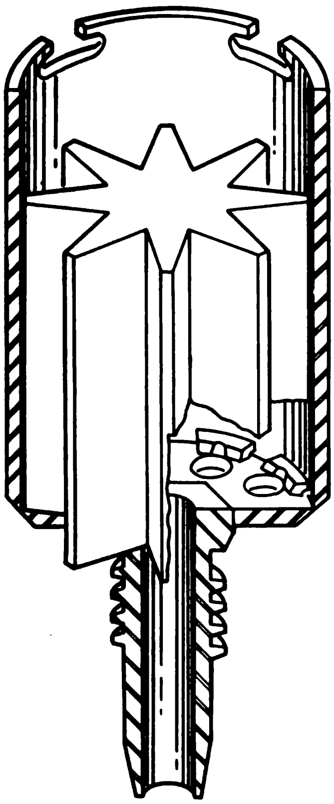


Fig. 21 Filter element and casing.

made of sintered type 304 stainless steel and is enclosed in a casing designed to prevent damage by twisting during installation or removal. The Acme-threaded connector at the bottom of the element screws into the bottom of the filter tank when the element is installed. The filter is installed or removed by a long-handled wrench which fits into the slots in the casing. The wrench and element are raised or lowered by a winch. Used elements are pulled out of the feed preparation cell into a shielded carrier similar to a fuel element charger that travels along a track at the top of the cell.

Instrumentation. Standard industrial instruments are used throughout the plant for remote control of the process operations. In general, indicating instruments are used for the batch-operated portions of the process and the process operations are controlled manually. In the continuous-extraction cycles, automatic control instruments are used extensively, although some stream flows are controlled manually.

Many types of radiation and contamination monitoring equipment are used in the plant for the protection of personnel and to monitor the decontamination performance of the process. These instruments also are commercially available types.

Most process control instruments are of the air-purge type with transmitters mounted on the back of the instrument panels in the operating corridor (Fig. 10). The instrument lines are run across the ceiling of the access corridor so that there is always a point higher than the process vessel being served, through the cell wall and to the vessel. It has been found desirable to locate the transmitters as close as possible to the process vessel being served to minimize time lags. Some transmitters have been relocated at the cell walls for this reason. It is desirable to locate the transmitters above the level of the process vessel served in order to reduce the chance of contamination by solutions backing up the purge lines, but this is not the case for a few of the plant instruments.

There are no flow measurement instruments in the radioactive portions of the plant. Flow rate control, when necessary, is accomplished with manually or automatically controlled metering pumps. The flow rates are checked by observing the decrease in level in vessels or burettes provided for this purpose.

Solution weights and specific gravities are measured by pneumatic instruments using an air-purge system. Purge air is admitted to the instrument lines through rotameters and bubbles out through the instrument dip legs in the process vessels. The differential pressure across two dip legs is measured by a transmitter or aneroid manometer that actuates the pen on the record-

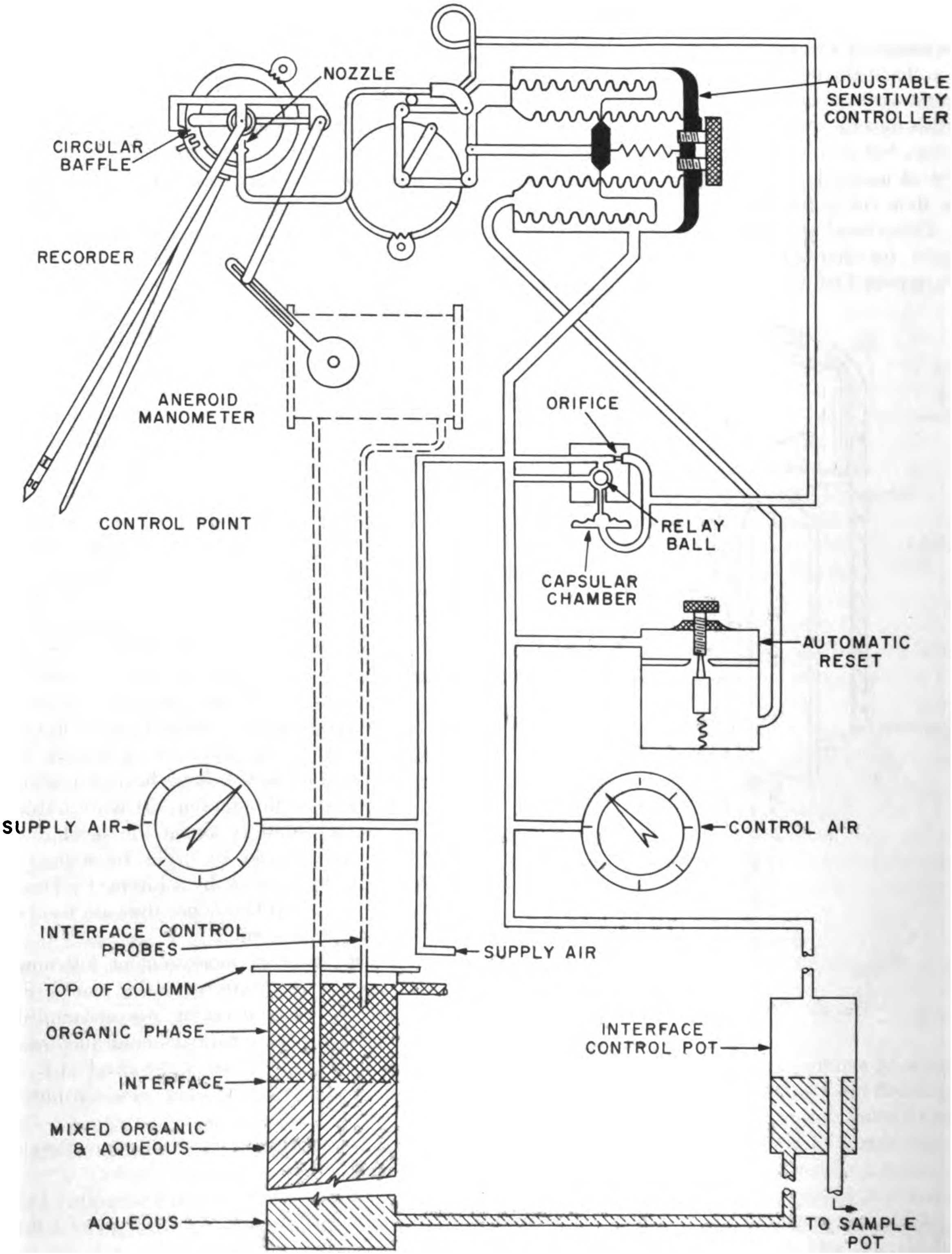


Fig. 22 Column interface control.

ing unit. Knowledge of the location and spacing of the dip legs permits calculation of the density or solution weight from the differential pressure.

The aqueous-solvent interface position in the columns is recorded and controlled by a similar system. The instrument dip legs in the column measure the differential pressure across the interface, which is an exact indication of the interface position because the densities of both phases are known. The controller output air pressure is fed through a reducing relay to the column jackleg pressure pot to control the aqueous outflow rate, and thus the interface position. The interface control system is shown in Fig. 22.

The intercycle evaporators are also controlled by pneumatic instruments. The steam rates to the evaporators are controlled by the weight measurement, and the product outflow rate is controlled by the evaporator density. The output air pressure from the density controller actuates metering pumps in the case of the first- and second-cycle evaporators—an air-operated diaphragm valve is used in the case of the third-cycle evaporator—and thus regulates the product output rate. The dip legs for these measurements are shown on the sketch of the evaporators (Fig. 16).

On the feed preparation tanks, where extremely accurate measurement of the solution weight is necessary for plant input measurements, manometers are installed in parallel with weight recording instruments to provide a constant check.

Most of the pneumatic instruments are hooked into alarms which sound when the liquid level or density goes out of the normal operating range.

Liquid-level displacement meters are used for measuring solution weights in the product transfer pots and product loading burettes. As the level in the vessel rises, a displacement float displaces more liquid. The displacement force thus generated causes a slight rise of the float, which in turn rotates a torque tube through a small angle. A transmitter translates the rotation of the torque tube into output air pressure, proportional to the solution weight, which is then transmitted to a recorder. This type of instrument is not suitable for use in high-radiation-level locations because the transmitter must be located next to the vessel, where it would not be accessible for servicing.

Electrodes are used for actuating sump alarms and indicating high liquid levels in tanks such as filtrate receivers that are operated under vacuum. These have not proved entirely satisfactory, as salt from the process solutions deposited on the insulation can eventually cause a short circuit. Air-purge systems are being developed to replace the electrodes in some locations. On several of the sumps the electrode alarm automatically actuates a steam jet which empties the sump.

Thermocouples are used for temperature indication in remote locations. The thermocouples are installed in stainless-steel wells in the process vessels so that they do not come in contact with the process solutions. The thermocouples are connected into conventional indicating or recording units on the panel boards.

DECONTAMINATION OF EQUIPMENT FOR MAINTENANCE

Necessity. As radiation levels in the process cells are estimated to run as high as 10^6 r/hr during operation, the process equipment must be decontaminated before personnel can enter the cells to perform maintenance work. During plant operation, very little maintenance has been required, as evidenced by the fact that the plant has averaged greater than 98 per cent on-stream operating-time efficiency for all processing runs. During 14 months of actual processing operations, it has only once been necessary to enter a high-radiation-level cell. However, the plant has been decontaminated twice during scheduled shutdown periods, once to allow for general maintenance work on the equipment and once to allow construction personnel to enter the plant to install additional processing equipment. During this second shutdown some general maintenance was also performed.

It is difficult to predict the frequency of shutdowns for decontamination and general maintenance actually needed for a direct maintenance plant of this type. Based on experience to date, it appears that about 30 days per year should be allowed for this purpose, while another 30 days

should be allowed for emergency maintenance and the correction of process difficulties.

Decontamination Methods. The thorough flushing of process solutions from the process vessels is the first step in decontamination operations. This is accomplished by water and dilute acid flushing and by steaming with live steam admitted through the spargers or solution addition funnels. Appreciable quantities of uranium are usually recovered in the first flushes, and they must either be sent on through the process or sent to the salvage equipment for eventual recovery. In some cases, steam and acid flushes will decontaminate the equipment sufficiently to allow small maintenance jobs to be carried out without additional decontamination.

After flushing, the equipment is decontaminated with chemical solutions. Chemical decontamination procedures are based mainly on past experience gained at this plant and at the ORNL pilot plant where the MTR recovery process was developed. The mildest decontaminating agents are used first, followed by the more corrosive solutions. The standard decontamination agents in the order usually used are (1) 10 per cent nitric acid, (2) 10 per cent citric acid, (3) 10 per cent sodium hydroxide–2.5 per cent tartaric acid, (4) 10 per cent oxalic acid, (5) 0.003 *M* periodic acid, and (6) 3 per cent sodium fluoride–20 per cent nitric acid.

The vessels are filled to slightly over normal working volume with the decontaminating solutions, heated by steam sparging or jacket steam, and agitated over the contact period. The solutions are usually held in the vessels for 8 hr at boiling or near-boiling temperature. Exceptions to this are oxalic acid solution, which is heated to a maximum of 75°F, and sodium fluoride–nitric acid solution, which is left in contact with the vessels for a maximum time of about 1 hr at room temperature. The solutions are transferred between vessels during the operations to decontaminate the transfer lines. Spent decontamination solutions are disposed through the process-equipment waste system.

Although some of the decontaminating solutions used do attack stainless steel to a slight extent, the short contact times used are believed to keep the vessel corrosion to a minimum. Examination of the interior surfaces of some of the vessels after the last decontamination has shown that corrosion during the decontamination operations was negligible.

Off-gas lines, vent lines, knockdown towers, and other equipment not normally contacted with process solutions are decontaminated by steaming. Chemical solutions can be backed into these lines by overfilling the process vessels, but this is seldom necessary.

During the internal decontamination operations, the external surfaces of the equipment and cells are decontaminated by spraying water and/or admitting live steam to the cells. When the cell radiation levels are low enough, the residual external contamination is removed by scrubbing with detergent and chemical solutions.

Sampler stations are decontaminated by recirculating decontaminating solutions from the process vessels through the samplers, steaming down the internal portion of the stations, and cleaning up residual contamination with detergent and chemical solutions.

Contamination spread to the personnel areas is cleaned up by scrubbing or, in the case of bad spills, by removing sections of the asphalt tile used to cover the floors.

During all decontamination operations, health-physics personnel are present to monitor radiation levels and safeguard the operating and maintenance personnel from overexposure.

Efficiency. The only time entrance to a high-radiation-level cell was necessary during plant operation occurred during the first plant run. Fuel elements cooled for two years and longer were processed during this run, and thus the decontamination before entering the cell was somewhat easier than would be possible during a short-cooled fuel-processing run. The feed-stream radioactivity level was about 10 curies [1] per liter.

[1] Radioactivity concentrations given in this report are based on beta radioactivity counting of actual process solution samplers on the second shelf of a beta proportional counter. Counting efficiency is assumed to be 10 per cent.

During this run the first-cycle extraction-column feed pot became plugged and it was necessary to shut down the extraction process. The contents of the column were jetted to the salvage equipment and the column was steamed for 30 min. The column was then flushed with water and jetted to salvage again. The radiation level at the column was found to be 1500 mr/hr at this time, and maintenance personnel were allowed to enter the cell with limited working time. The line to the feed pot was removed and the nozzle capped, and the feed pot and line to the column were flushed with steam and water to bring the feed-pot radiation level down to 500 mr/hr. Two new sections of pipe were installed, and the columns were started up and operated satisfactorily. The total plant down time was 25 hr. The weekly radiation exposure limit (300 mr/hr) was reached by four maintenance and two operations personnel during these operations.

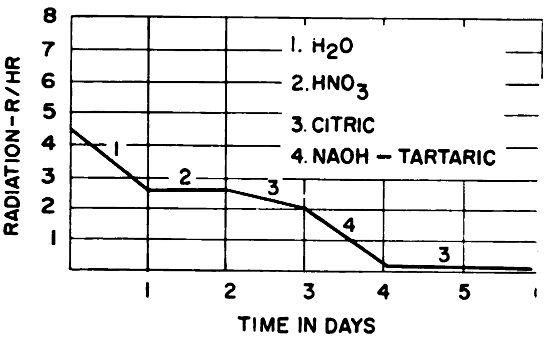


Fig. 23 Decontamination progress graph. After low-level operation.

Following the first relatively low radiation-level run (feed activity of 10 curies per liter), the equipment in the feed preparation, first extraction cycle, and first-cycle aqueous-waste cells was decontaminated to make it possible to enter the cells, check the equipment, and make minor repairs. The radiation levels in the remaining cells requiring entrance were low enough, after flushing during the process shutdown, to allow maintenance work to be carried out without decontamination. The extent of the decontamination required in each cell was determined by the time required to complete the work based on a maximum daily radiation dose of 60 mr.

Decontamination progress curves for two typical process vessels—a dissolver vessel and the first-cycle extraction column—are shown in Figs. 23 and 24. Radiation levels at contact beginning after the initial flushing at the time of shutdown are plotted against time on these figures, and the decontamination methods used are indicated.

The dissolver required 6 days of decontamination with water, nitric acid, citric acid, and sodium hydroxide–tartaric acid solutions to reduce the contact reading from 4.5 to 0.05 r/hr. The decontamination results for this vessel are typical of the results obtained for all the feed preparation vessels.

Steaming of the extraction column and removal of the packing reduced the radiation level from 20 r/hr down to 0.5 r/hr. No other decontaminant was used. The relative ease with which this column was decontaminated in comparison with the batch-operated feed preparation vessels indicates that the continuous use of equipment without intermittent idle time makes the vessels easier to decontaminate.

The second plant decontamination was much more difficult to carry out. Just prior to this decontamination, short-cooled feed solutions of 150 curies per liter had been processed. Also, the decontamination had to be continued to much lower radiation levels (7.5 mr/hr general background) so that construction personnel, who were unfamiliar with the effects and techniques

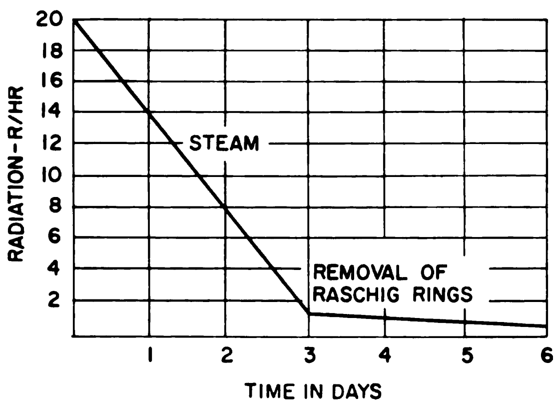


Fig. 24 Decontamination progress graph. After low-level operation.

for the control of radiation, could be allowed safe access to the process areas for nearly unlimited working times. Several months were available for this decontamination and only a limited number of personnel were available so that decontamination was not carried out at anywhere near the speed with which it could be accomplished on an emergency basis. From 10 to 30 days was taken to decontaminate each process vessel. It is believed that the job could have been done in about 1 week with efficient scheduling of operations and sufficient manpower.

Because of the high radiation level of the vessels at the end of the run, it was not possible to enter the cells and determine radiation levels at the individual vessels. For example, shortly after decontamination operations had started, the level just inside the A Cell door was over 100 r/hr. In many cases two or more decontamination steps weie finished before it was possible to monitor the process vessels to determine the effectiveness of the decontamination procedures.

Cell A (dissolving and feed preparation) proved to be the most difficult area to decontaminate. The radiation level at the entrance to this cell was 30 r/hr after 7 days of internal decontamination. After external decontamination of the vessels and additional internal decontamination with the standard solutions up to and including sodium hydroxide–tartaric acid, the average radiation level at contact with the vessels was 1.5 r/hr. Oxalic acid solution was used next with little effect. Treatment with periodic acid followed by nitric acid proved to be very effective at this point, and the radiation levels at contact were reduced from about 1.2 r/hr to about 250 mr/hr after several treatments. A few lines and vessels required additional treatment with sodium fluoride–nitric acid solution. The decontamination of the A Cell vessels required an average time of 23 days to reduce the average radiation levels at contact to 60 mr/hr. It is interesting to note that about 75 per cent of the time used was required to reduce the level from 5 r/hr to 60 mr/hr.

Decontamination progress for a dissolver is shown in Fig. 25. The curve shows an increase in radiation level after some decontamination steps; this is believed due to cross-contamination from other vessels during the transfers of decontaminating solution. The results for the dissolver are similar to those obtained for all A Cell vessels.

Similar procedures were followed for the other process cells and the results were much the same except that decontamination was easier and was usually accomplished in less time.

The first extraction column required 15 days to reduce the radiation level to 280 mr/hr at contact as compared with the 6 days required for nearly complete decontamination after the first run. Steam, nitric acid, citric acid, and sodium hydroxide–tartaric acid solutions were needed to complete the decontamination. These results again illustrate the ease of decontamination of continuous equipment as compared with batch equipment.

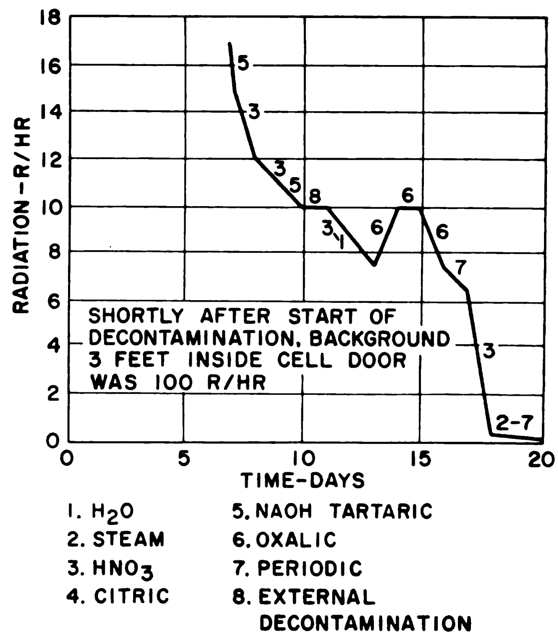


Fig. 25 Decontamination progress graph. After high-level operation.

Advantages over Remote Maintenance. The choice between design of radiochemical processing plants for direct instead of remote maintenance should be made primarily on the basis of plant scale. In plants designed for the recov-

ery of plutonium from large quantities of irradiated natural uranium, it is probably desirable to provide for remote maintenance or removal of the equipment since the large-scale equipment in these plants would be hard to decontaminate and maintain directly, primarily because of its large size. On the other hand, it is believed that design for remote maintenance would be nearly impossible for an enriched-uranium processing plant because the many small-diameter critically safe vessels required would be very difficult to adapt to the special connectors, piping jumpers, and other specialized apparatus required for remote-maintenance plants.

Direct-maintenance plants can be built using commercially available equipment and equipment fabricated according to standard industrial techniques. The cell space can also be used more efficiently as the equipment pieces can be stacked two- or three-high. These factors add up to an appreciable saving in initial plant cost, which, it is believed, more than offsets the costs and time consumed for equipment decontamination prior to maintenance operations.

The operating experience at the Idaho Chemical Plant has definitely proved the feasibility of designing and operating a production-scale radiochemical plant using direct-maintenance techniques. This experience has shown that a properly designed direct-maintenance plant requires essentially no hot-cell maintenance. Maintenance operations should be required in these areas for only five reasons: (1) equipment failure because of corrosion, (2) failure of the remote-head pump diaphragms (when the heads are located in cells), (3) remote valve failures, (4) plugging of the lines or equipment, and (5) solution leaks due to faulty construction or to use of unreliable connection methods. Proper choice of construction materials, installation of spare equipment, location of all equipment with a high maintenance potential in cubicles outside the cells, reduction of the number of valves to the absolute minimum, provisions for flushing the equipment from cold areas, welding all piping connections, and thoroughly leak-testing all equipment with simulated process solutions and Freon before startup can all but eliminate these potential maintenance problems.

ANALYTICAL SECTION OF THE IDAHO CHEMICAL PROCESSING PLANT

The analytical section of ICPP consists of four groups. They are (1) the shift control group, (2) the special analysis group, (3) the spectral analysis group, and (4) the analytical development group. The shift control group is composed of both chemists and technicians. They follow the plant shifts and handle all samples that require immediate analysis to maintain operations. The special analysis group handles all samples that are not of a routine nature or that require special techniques, such as final product analysis, fission-product spectrum, active gas samples, etc. The spectral analysis group performs all mass spectrographic analysis on both solids and gases, emission spectrographic analysis, and x-ray diffraction and fluorescence analysis. The analytical development group maintains a quality-control program on all routine analyses, trouble-shoots, improves methods and equipment, and prepares manuals of methods.

Facilities. Three types of laboratories—cold, semihot, and hot—are maintained. The cold laboratories are of sufficient size to house the spectral analysis group and the analytical development group. They have the usual accommodations of any chemical laboratory. The semihot laboratory has, in addition to the things in the cold laboratories, a lead storage rack for storing radioactive samples. This laboratory accepts samples having radiation readings up to 1 r at contact. Microportions of such samples can be handled on the bench without danger to the analyst, but the samples are stored behind 2 in. of lead. When the radiation level becomes greater than 1 r, remote handling is used to protect the analyst. This requires a specially designed hot laboratory.

Equipment. In addition to the usual analytical apparatus, the analytical section has the following equipment available for use in the remote facility:

1. Remote pipettes for measuring microliter quantities of sample.
2. Polarographs for uranium analysis.

3. Fluorophotometric apparatus for small amounts of uranium.
4. Specific gravity by the falling-drop method.
5. Acid titration apparatus.
6. Decontamination apparatus to decontaminate samples for mass analysis.

The semihot laboratories have the same equipment as above, except that it is not designed for remote operation.

The counting room for determining activities is equipped with:

1. Alpha counters.
2. Geiger counters.
3. Beta proportional counters.
4. Gamma scintillation counters.
5. Gamma high-pressure ion chamber.
6. Gamma scintillation spectrometer.

The spectral laboratory has available:

1. Mass spectrometer, thermal emission equipped with vacuum locks for introducing solid samples without undue loss of vacuum.
2. Mass spectrometer similar to those used for general gas analysis.
3. Emission spectrograph with three-meter grating.
4. X-ray diffraction unit with wide-range goniometer, electronic circuit panel, and x-ray spectrograph attachment.
5. Densitometer-Comparator with recorder and film adapter.
6. Flame spectrophotometer.

HEALTH PHYSICS AT CHEMICAL PROCESSING PLANT

Personnel at the Chemical Processing Plant are exposed to hazardous radioactive materials in addition to the ordinary hazards of a chemical industry. It is known that radiation will kill all living cells if applied in sufficient dosage, and that man is exposed to radiation from natural sources throughout his life without apparent damage. There is a level between these two extremes where human beings may be exposed routinely throughout their lifetime with the most remote possibility that damage will ever be detected. Hence, according to our present knowledge, the nearer the exposure approaches to background radiation, the lower the probability of injury.

Principles of radiation protection have been adopted that allow radiation exposure to approach the background level as near as is practical, considering the nature and cost of operation, but which never allow exposure to exceed recommended limits. These do not necessarily guarantee that the levels are completely harmless; a lifetime of exposure at these levels could involve risk. However, since any human activity involves some risk, individuals are expected to accept hazards of radiation exposure that do not exceed other risks already present.

It is recognized and emphasized that, regardless of instruments, alarm devices, rules, and procedures, individuals must assume considerable personal responsibility for their own protection from injury by radiation.

Definition of Responsibility. The project manager is responsible for the safe operation of the plant. This responsibility is delegated downward through the superintendents of various branches. The health-physics section has been established to advise the project manager of precautions necessary to control or avoid hazards resulting from work with radioactive materials. The various sections assume responsibility for safeguarding the health of individuals under their jurisdiction. These sections call upon the health-physics section for the location, measurement, and evaluation of radiation hazards, as well as for recommendations for their control or elimination. The supervisors are responsible for keeping the health-physics section informed of the nature and extent of the work involved in all operations, so that necessary information may be accumulated and recommendations prepared. The health-physics section, in turn, is obligated to inform the various sections of the existence and nature of radiological hazards resulting from work anticipated or already in progress.

The health-physics section maintains necessary records and compiles measurements and data required to assure the project manager that the operation of the plant conforms to radiological regulations established by the Atomic Energy Commission and the National Committee on Radiation Protection and are safe according to company standards.

Permissible Radiation Levels. *External.* Employees are allowed to receive a maximum of 3.9 rep of whole-body radiation per calendar quarter of a year. There are no official limits on the rate at which this exposure is received, although, for our own protection and convenience, employees are not ordinarily allowed to receive greater than 0.6 rep in one week and are discouraged from allowing the total quarterly exposure to exceed 0.3 times the number of weeks past at any time during the quarter.

Internal. Recommendations of the Subcommittee on Permissible Internal Dose of the National Committee on Radiation Protection, as published by the National Bureau of Standards, in Handbook 52, are used as limits for air-borne radioactive materials.

Contamination limits. 1. Areas. We have intentionally avoided the establishment of numerous fixed limits of contamination for various areas. Health physicists examine the degree of hazard and make recommendations based on risks due to direct radiation, ingestion, and inhalation. Their recommendations are often based on elimination of the hazard as contrasted to removal of the contamination. Isolation and/or controlled entrance to contaminated areas has often been much more economical than removal of the contaminated materials, particularly where areas tend to become contaminated repeatedly. Raising the allowable contamination level, where it can be done without unnecessary risk, by a factor of 2, for example, may usually be expected to lower the cost of decontamination to the lower level by a factor of much greater than 2.

2. Personnel and Clothing. Employees may do their own monitoring with various alarms, hand and foot counters, and scaler probes provided for that purpose. We have found it advantageous to post the limits on the monitoring device and publish them. Limits are given in Table 3.

Additional limits largely for the use of health physicists are given in Table 4.

Emergency limits. Emergency radiation exposure limits much higher than those mentioned are published only for the benefit of responsible supervision and health physicists for use in a *real* emergency. They have never been used.

Radiation Present. Only beta, gamma, and alpha radiation, in the order of decreasing abundance, are present at the Chemical Processing Plant. Alpha radiation is almost entirely confined to uranium and has been a minor problem.

Table 3 Permissible Contamination Levels for Personnel and Clothing

Surface of skin or clothing	Type of contamination	Maximum permissible contamination
Skin—general body contamination	All	Any detectable contamination to be reported to health-physics field office
Skin—hands	Alpha (not readily removable)	Less than 500 dis/min over 100 cm^2 of surface
	Beta	Permissible level as indicated on hand and foot counter
Shoes—personal	Alpha	Less than 500 dis/min over 100 cm^2 of surface
	Beta, gamma	1000 cpm * (inside or outside)
Shoes—issue—not to leave plant	Alpha	500 dis/min (100 cm^2 of surface area)
	Beta, gamma	10,000 cpm * (outside) 1000 cpm * (inside)
Clothing—personal—levels above which clothing will be impounded	Alpha	500 dis/min (100 cm^2 of surface area)
	Beta, gamma	500 cpm *
Clothing—protective	Alpha	500 dis/min (100 cm^2 of surface area)
	Beta, gamma	1000 cpm *

* As measured with a standard Geiger-Müller probe, under the best geometrical arrangements.

Table 4 Additional Permissible Plant Contamination Levels

	Beta, gamma *	Smear †	
		cpm (beta) gamma	cpm (alpha)
Vendors' containers—food	None detectable	20	10
Materials to company shops	Less than 1 mrep/hr	50	10
Materials leaving controlled area (acid bottles, carboys, gas cylinders, etc.)	Less than 0.4 mrep/hr	50	10
Commercial carriers leaving controlled area	ICC regulations	50	10
AEC controlled carriers	ICC regulations	50	10
Radioisotope containers leaving controlled area	ICC regulations	50	10
Salvage material	Less than 0.4 mrep/hr	50	10
Material to stores, glass shop, etc.	None detectable	20	10
Instruments to AEC health physics calib.	Less than 0.4 mrep/hr	50	10

* There must be no detectable alpha with such instruments as the Zeuto or Samson.

† A smear shall be interpreted as wiping 40 in.^{2} of surface (four 10-in. passes) with 2-in.-diameter Whatman 50 filter disk or equivalent and counting at 10 per cent geometry for beta-gamma in a standard mica end-window Geiger-Müller counter, and 50 per cent geometry for alpha in a parallel-plate ion chamber or gas-flow proportional counter.

Gamma emitters of intensities sufficient to result in fatalities from a few seconds' whole-body exposure are routinely handled: under water in the storage areas, in lead shields during transportation, and in concrete cells during processing. Beta radiation is commonly shielded by containers; however, since materials are in a liquid state throughout most of the process, it is not impossible or completely uncommon for limited amounts of beta and gamma emitters to occur unshielded. No cases of physical damage have been detected nor are they expected.

Radiation and Contamination Protection and Control. A complete description of all methods and procedures is impractical here. Some of the major methods will be mentioned briefly.

Health-physics indoctrination lectures. All new employees receive a minimum of 2 hr instruction on the hazards and methods of control peculiar to this plant. They are provided with applicable pamphlets outlining hazards in nonscientific terms, as well as copies of procedures which are expected of all employees.

Supervisory instruction. Supervisors carefully instruct each new employee regarding the specific details of his particular job and supervise the work until it is done satisfactorily and without unnecessary risk.

Buddy system. Experienced employees work with new men until they have achieved satisfactory performance and awareness to hazards. A few areas are never entered by an unaccompanied employee.

Locked areas. Areas are locked where seriously damaging exposures are possible. Keys are in the custody of the shift supervisor and are released only on his specific direction and under his responsibility.

Protective clothing. Experience has shown that errors will be made and accidents occur that result in the transfer of radioactive material to the individual and his clothing. Employees are issued protective clothing.

Some clothing is "protective" in the sense that it is not only worn exclusively in the plant, and therefore for shorter periods than personal clothing, but is frequently monitored and laundered. Specialized clothing, such as several kinds of gloves, shoe covers, caps, rubber suits, and respiratory protective equipment, are available on request.

Differentiated areas. Areas within the perimeter fence are divided into potentially radioac-

tively contaminated areas and radioactively clean areas. The former are for those wearing protective clothing only, and the latter for street clothing or protective clothing covered by laboratory coats and shoe covers. Clean areas include the cafeteria, top-floor offices and medical facilities of the Laboratory Building, and the Utilities Building.

Change areas. Entrance to the principal buildings is by a vestibule, exits from which go to the main clean area (cafeteria and offices) or to the locker rooms. Double lockers are used, one for protective clothing and one for personal clothing. They are adjacent to each other so that vigilant monitoring by the health-physics section is required to prevent contamination of personal clothing. Employees are encouraged to change their protective clothing frequently. It is monitored for radioactive materials and divided into three classifications (in order to prevent contamination of uncontaminated clothing by highly active garments) before being sent to a special laundry.

Contamination monitoring. Hand and foot counters are available in most accessible places. They are activated by stepping on them. The contamination limits are posted on each for comparison with the results registered. It requires approximately 15 sec for an employee to monitor his hands and feet. Four passageways are automatically monitored by quintectors which sound an alarm in the presence of even low-level radioactive materials. These are the main gate (two passageways), the entrance from potentially hot areas to the men's locker room, and the cafeteria.

The exit from the locker rooms, through which all personnel must pass, are monitored by a stiletron. This consists of Geiger tubes arranged under the feet and on each side of the body. The device sounds an alarm in the presence of beta or gamma activity and locks the exit turnstile. It is released when the contaminated individual passes through a second turnstile back to the locker room. Lights indicate the parts of the body contaminated.

Personnel monitoring. Each regularly employed individual picks up his own film badge and one pocket chamber at the main guard gate. These are worn continuously. He returns each to its proper place at the end of the shift. The pocket chambers are read daily and the film badges weekly, unless a pocket chamber has indicated greater than 100 mr, in which case the film badge is developed and read.

These devices are read by the Health Physics Division. They report gamma readings only on the pocket chambers, and beta and gamma readings on the films. The gamma reading is obtained by reading the milliroentgens as determined from a radium-calibration curve. The beta reading is obtained by subtracting the gamma density behind the shield from the open-window density and reading the remainder on a beta-calibration curve. Film rings and dosimeters are issued from the Health Physics Field Office for special jobs.

The maximum permissible limit for whole-body exposure at the Chemical Processing Plant is 3900 mrep per calendar quarter. Since beginning hot operation in February, 1953, only two persons have exceeded this limit. One had a quarter exposure of 3940 mrep and the other had a quarter exposure of 4030 mrep. Both individuals received their high exposure in cells during a shutdown.

If any employee exceeds 300 mrep in one week, an investigation is made and a written report is submitted to the employee's supervisor, listing the amount of exposure, where the exposure occurred, and the recommendations of the health physicist. If an employee is exceeding his weekly exposure limit, he is restricted entry into radioactive areas.

Body-fluid samples. Approximately 50-ml samples are collected a minimum of 2 hr after exposure to air-borne materials or possible ingestion. Analyses are made for beta-gamma materials and are reported as beta disintegrations per minute per 5 ml. Samples showing significant results are followed by repeat samples until they have reached background. All cases to date have reached background in 3 weeks or less.

Routine samples are collected of all personnel: a minimum of once a year for administrative employees who are not directly associated with radioactive materials; twice a year for supervisors and others who visit hot areas but do not handle materials themselves; and four times a

year for those who actually work with radioactive materials, including maintenance, instrument, and others as well as operators and laboratory personnel.

Medical examinations. Preemployment examinations are required; periodic examinations are not mandatory. Termination examinations are made on the recommendation of the health physicist based on the type of work done and the exposure received. Blood counts aimed at detecting radiation damage are not made; sufficient radiation to cause significant blood changes has never been received.

Instruments. Except for the stiletron and liquid-waste monitor, all instruments are commercially available. Ample supplies of Geiger-tube-type instruments (range to 20 mrep/hr) and ionization chambers (ranges to 5, 25, and 500 rep/hr) are available to health physicists and for loan to supervisors for measurements at locations required. Alpha-detecting ionization chambers are also available, as are beta, gamma, and alpha counters, including gas-flow proportional counters. The counters are used in the Health Physics Field Office without unusual electrical or radiation shielding. Ordinary commercially available lead shields are used on the counters.

Alarm-type monitrons are located throughout the buildings. Those in usually occupied areas register their alarm at a central point where readings are recorded. Others alarm at the location of the chamber and readings are not recorded.

Constant air monitors alarm in the presence of air-borne radioactive materials. Activity collects on filters which produce a reading on a rate meter by means of a Geiger tube shielded from direct radiation. These are supplemented by spot samplers designed to collect samples in 5 to 30 min and by means of counting a $1\frac{1}{8}$-in. filter disk, the concentration is computed. Other filter samplers are designed for continuous operation but require counting and computation of concentrations.

Drinking-water monitoring. Since liquid wastes are discharged to the water table at a point relatively close to the supply wells, at a point believed to be downstream from the intake, two samples per week of potable water are analyzed for radioactive materials. The Health Physics Division also monitors surrounding wells for radioactive materials. No detectable variations from background in regard to radioactive materials have been detected.

Removal of equipment. Known hot materials are transferred from person to person by signature, never from area to area. Those eligible to receive hot materials are aware of hazards and are responsible for having radiation and contamination levels checked and made to conform to safe limits.

Nothing is accepted by supervisors in cold areas unless it is accompanied by a "removal tag," properly signed and dated by a health physicist. Patrolmen refuse exit at the main gate to all articles not so accompanied.

Radioactive shipments. Radioactive materials being legitimately removed from the area are accompanied by the removal tag above and a properly executed Radioactive Shipment Record, prepared by a health physicist, certifying conformance to Interstate Commerce Commission or other applicable regulations.

Work permits. Maintenance, instrument, or other personnel not ordinarily responsible for conditions in various areas perform work there only in conformance to a Safe Work Permit, prepared in triplicate, originated by the supervisor requesting the work, and signed by a health physicist and/or the safety engineer, stating definite requirements.

Decontamination. 1. Areas and Equipment. Most floors subject to contamination are covered with asphalt tile and a heavy coat of wax. Strong detergents that remove the wax have been very successful in decontamination. They are applied with mops or by scrubbing with sanitary pads. Tools are scrubbed with detergents or soaked in various reagents, including versene in relatively high concentrations. Tools that are not cleaned by these methods are transferred to the Health Physics Section, which decontaminates them electrolytically or by blasting, at intervals determined by the number accumulated. Shoes are decontaminated by a revolving bristle or wire brush. This has been effective on accessible parts of shoes.

2. Personnel. Bradley fountains in the men's locker room contain detergents and brushes for

hand scrubbing. Decontamination solutions consisting of (1) 0.3 *M* citric acid, 0.5 *M* hydrochloric acid, and 0.1 per cent Aerosol and (2) 1 per cent detergent, 5 per cent versene, and a trace of phenolphthalein for color, are available from 18-liter carboys through dispensers. If these do not accomplish results, health physicists provide stronger reagents. Hand lotions containing lanolin are available after intensive scrubbing.

Ordinary bath soap followed by tincture of green soap is most widely used for decontamination in the showers.

Directions for the use of these solutions are posted at the points of use.

Routine surveys. A chart of all areas requiring routine surveys and the number of surveys per unit time is posted in the Health Physics Field Office. Different shift crews divide the surveys, which are usually conducted on the evening or night shift when the work load is likely to be lighter. Recommendations resulting from these routine surveys are given to the supervisors for necessary action.

Calibration. Fixed instruments, including hand and foot counters, monitrons, and air monitors, are calibrated according to written procedures at stated intervals by health physicists on night shifts. Portable instruments are sent to the Health Physics Division for calibration. The Atomic Energy Commission repairs portable instruments and the Chemical Processing Plant Instrument Section repairs fixed instruments.

Wastes. *Solids.* All radioactive materials associated with solids are carried by special truck to the Atomic Energy Commission burial ground. The solid wastes are packed in leakproof containers to prevent the spread of contamination of the truck bed or of the highway en route. Pickup at the Chemical Processing Plant area is made twice a week. No control on the amount of activity sent to the burial ground is kept other than limiting the quantity sent in one truckload to prevent excessive exposure to handling personnel. Highly radioactive wastes are sent to the burial ground in a special trailer that may be loaded and dumped remotely.

Gases. The large quantities of radioactive gases evolved during the processing at the Chemical Processing Plant are generally discharged directly to the atmosphere through a 250-ft stack. No control on this discharge is generally attempted.

Liquids. Control of liquid wastes at the Chemical Processing Plant is accomplished by (1) concentrating and permanently storing the high-level wastes in large underground tanks, or (2) diluting and disposing of the low-level wastes to the water table through a disposal well drilled to a depth of 100 ft below the water table. Condensate from the waste evaporator and miscellaneous low-level wastes are sampled for activity and, if sufficiently low, are sent to the disposal well.

Located at the disposal well is a continuous proportional sampler. The sample is collected and analyzed daily for activity, thus providing a daily record of the total radioactivity discharged to the water table.

In addition, the monitoring station contains two counters to continuously monitor and record the concentration of radioactivity in the main weir. An alarm will sound if the concentration exceeds a predetermined level. The continuous-liquid-waste monitor will also record the total activity discharged to the disposal well over any given interval of time by electrically coupling the flow-rate meter and the count-rate meter to a watthour meter.

If the continuous-liquid-waste monitor alarms when radioactive liquids are being discharged from an unknown source, each one of the three incoming waste streams may be checked independently by the monitor, and the source then may be quickly located and corrected.

The discharge of radioactive liquids to the water table through the disposal well is limited to a radioactive concentration that will not exceed, under the worst possible circumstances, the maximum permissible drinking-water level (as given in the National Bureau of Standards Handbook 52) at the nearest National Reactor Testing Station boundary line located directly down the water gradient from the disposal well.

In effect, this means that drinking-water concentration for long-life isotopes must be maintained at point of discharge. These limits have not been exceeded since the operation of the plant began.

COSTS

Distribution of Capital Cost. The distribution of capital costs given in Table 5 is based on the design and construction costs of the Idaho Chemical Plant, exclusive of operator training costs, preoccupation expenses, and expenses incurred by the Atomic Energy Commission.

The total cost figures from which this distribution was calculated included some additional processing facilities and additional space requirements for future expansion that have not been discussed in this report. Nevertheless, it is believed that the cost distribution given in Table 5 gives a good approximation of the distribution to be expected in a direct-maintenance plant. The ratio of building cost to equipment cost is probably high due to the inclusion of extra space in the building.

Table 5 Summary of Idaho Chemical Processing Plant Costs

	Per cent of total cost		
	Material	Installation labor	Total
1. Process Building:			
Major process equipment	2.3	0.4	
Piping	3.6	3.3	
Instruments	1.4	0.9	
Electrical (process)	0.2	0.2	
Special equipment (samplers, fuel element chargers, etc.)	2.6	0.4	
Process Building and services	4.1	5.9	
Subtotal	14.2	11.1	25.3
2. Waste Disposal Building:			
Liquid-waste equipment	4.0	2.4	
Gaseous-waste equipment	2.4	0.9	
Building and services	1.5	1.9	
Subtotal	7.9	5.2	13.1
3. Administration and Laboratory Building with equipment	5.8	3.0	8.8
4. Fuel Element Storage Building	2.5	1.1	3.6
5. Service Building with equipment	1.5	1.2	2.7
6. Yard facilities	1.7	2.0	3.7
Total direct material and labor	33.6	23.6	57.2
Construction overhead, including contractor's fee	....	....	27.8
Engineering and design, including contractor's fee	....	....	15.0
Total physical plant costs	....	....	100.0

Laboratory Equipment

COMPILED BY BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

Laboratory Equipment

The functional design of a hot laboratory is based on facilities and operating equipment which assure a safe environment for handling and investigating radioactive materials.

In practice, radiation and contamination are reduced to tolerable limits by confining and localizing active materials in specialized enclosures equipped with remotely operated devices.

Hot Laboratory Design Features. Certain aspects of the design of hot laboratories evolved from past experience are reviewed here because the effectiveness of hot laboratory equipment is dependent on building structure and layout.

The layout of a hot laboratory involves the arrangement of rooms by activity levels that provide for a separation into high-level, intermediate-level, and no-activity areas. This plan facilitates the design and operation of the ventilation system. A floor plan of one hot laboratory (at the Brookhaven National Laboratory) is shown in Figs. 1, 2, and 3. Figures 4 and 5 are vertical sections taken through the main-floor layout of the hot area.

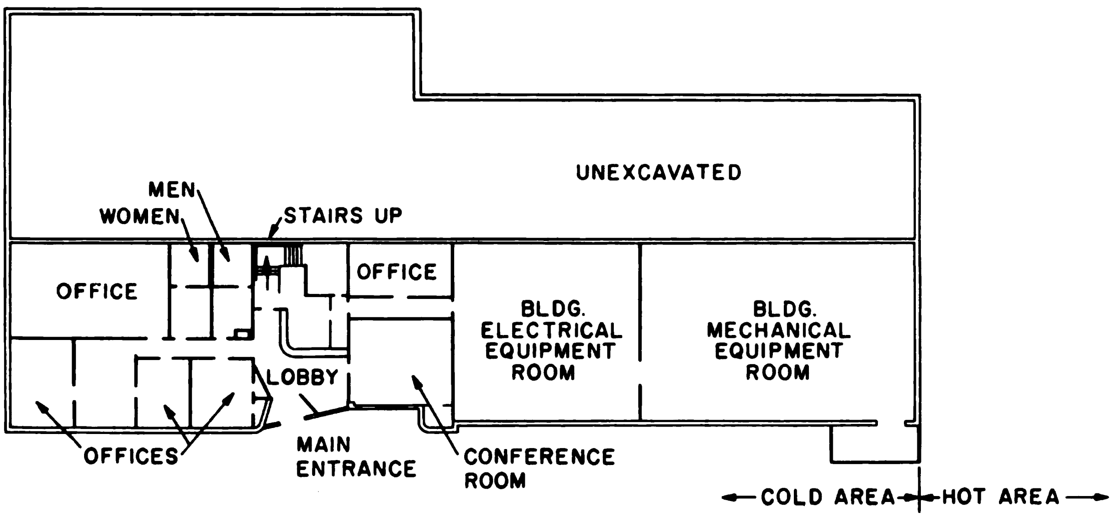


Fig. 1 Ground-floor plan of cold area located directly under part of the main-floor cold area. The building is constructed on a hill, situating both the ground-floor and the main-floor hot area at ground level.

The application, description, and operation of this equipment are presented in this section along with a discussion of the layout of an existing hot laboratory.

Documents and drawings listed under Reference Data are available for distribution. Requests for additional information should be referred directly to the Technical Information Service of the United States Atomic Energy Commission.

Ventilation is arranged to minimize air-borne contamination. Static pressure in areas where radioactive materials are handled is kept below

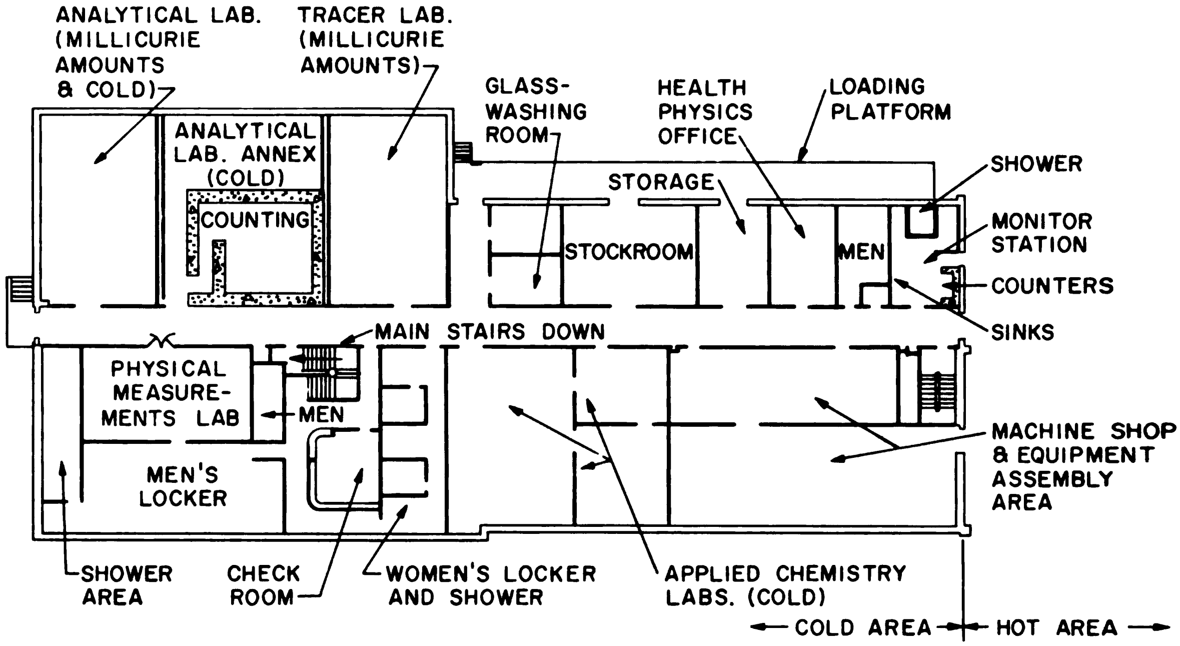


Fig. 2 Main-floor plan showing cold-area section. The monitor station contains three hand and foot counters, three surgical-type scrub-up sinks, a shower, a sanding belt for decontaminating soles of shoes, a cupboard for decontaminating solutions, rubber shoes for emergency use, and other essential items.

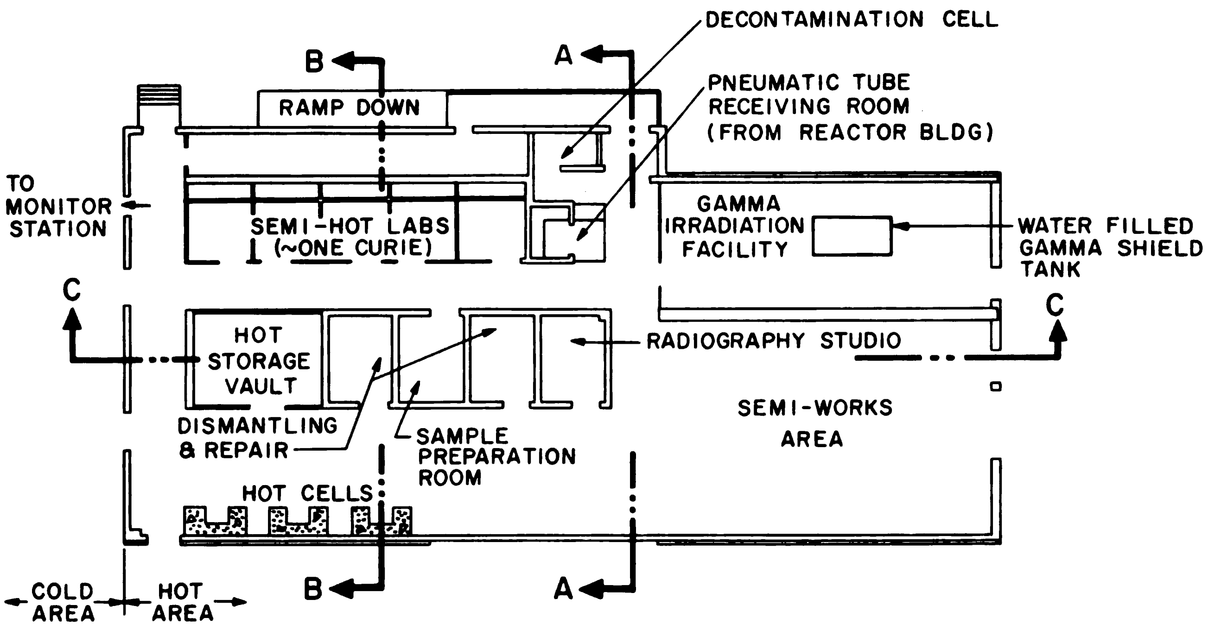


Fig. 3 Main-floor plan of the hot area. This section of the main floor contains the heavy shielding and is built directly on the ground. Sectional views *AA*, *BB*, and *CC* are shown in Figs. 4 and 5.

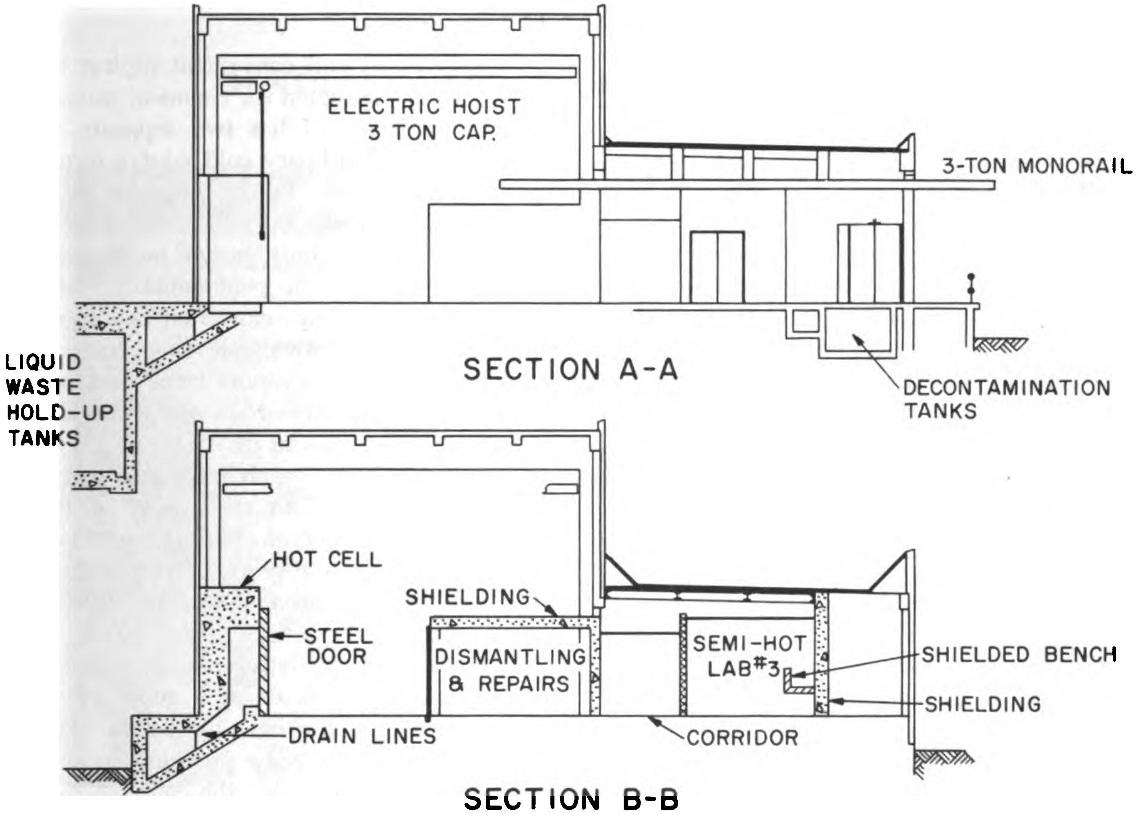


Fig. 4 Sections *AA* and *BB* through the hot area. The hot cell and semiworks area has a high ceiling and is serviced by an overhead crane. The semiworks area is a large open room with utilities on the walls; here pilot plants are set up and concrete-block shielding is erected as required.

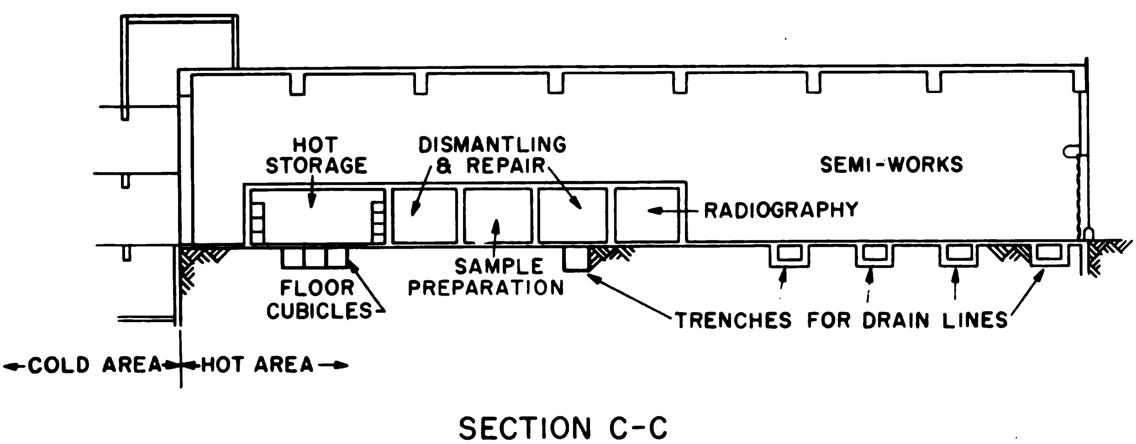


Fig. 5 Section *CC* through the hot area.

atmospheric pressure so that air flow is always from cold areas to hot areas.

Air from operating areas where personnel are working is exhausted, unfiltered, by roof fans. Exhaust air from hoods and enclosures is treated by filtering, scrubbing, or venting through a tall stack before it is discharged to the atmosphere.

Monitoring facilities are provided according to the degree of contamination anticipated. These include counters needed to monitor hands and feet and probe-type counters for detecting contamination in laboratory clothing. Equipment for decontaminating personnel includes surgical-type scrub-up sinks with foot-activated faucets, and showers. Provision is made for an adequate supply of laboratory coats, rubber gloves, and coveralls, in addition to facilities for collecting contaminated protective clothing for discarding or laundering.

The monitoring room is purposely located next to a hot area, making it necessary for all personnel to pass through it in order to get to a cold area.

Radiation levels are determined by the design of the shielding. Although the maximum permissible limit is 300 mr per week, shielding in operating areas is usually designed for a radiation level of 1 mr per hour or less.

Flexibility of laboratory operations is essential in order to accommodate a wide variety of work, ranging from tracer and cold experiments to the handling of high activities. For example, the design of a 1-curie activity building may include provisions for the addition of massive shielding or a water-filled pit for future handling of kilocurie activities.

Flexibility is also achieved by careful selection of equipment for manipulation and handling.

Adequate space is essential for operations that are difficult and dangerous to perform in cramped quarters.

Waste systems are designed to accommodate the waste resulting from decontaminating operations and chemical processes involving radioactive material. Wastes are handled in a piped drain system or in individual shielded containers, depending on the type of laboratory operations and the volume of waste.

An economical and convenient piping layout in a laboratory designed for chemical processing of irradiated material has two separate waste systems—one for ordinary cold wastes requiring no special treatment before disposal and the other for hot wastes.

Maintenance is a consideration in the location of equipment subject to contamination, such as sink traps. Drain traps can often be dispensed with by constantly drawing air through the drain to prevent fumes and vapors from backing up; where this is done, the drain can often double as an exhaust ventilation duct.

Surfaces of floors, bench tops, and walls are selected with regard to their ease of decontamination. Bare concrete, poorly painted wood, and stone surfaces are porous and readily soak up liquids, making decontamination difficult to accomplish.

Concrete floors are covered with plastic tile, linoleum, or several coats of a good chemical-resistant paint. Further protection against radioactive liquids may be provided by a layer of asphalt applied between the concrete subsurface and the top surface. Glossy painted surfaces are more readily cleaned than dull flat finishes.

Walls, floors, and equipment are painted with a strippable paint where the likelihood of contamination is high. A second coat of ordinary paint can be applied over the first, contaminated, coat to seal the activity inside. Then the two layers of paint can be peeled off together.

Exposed surfaces are reduced to a minimum by enclosing pipes and conduits behind walls or in ducts; this also simplifies decontamination procedures. Potential dust collectors, such as lighting fixtures, are selected with a minimum of projecting surfaces.

Central storage facilities for radioactive solutions, chemicals, and samples are located in a shielded vault sunk in the building floor or ground or in lockers above the ground.

Decontamination facilities to salvage contaminated equipment are set up according to the type and size of equipment and range from a large specially equipped dry box to a cleaning-bath tank.

GENERAL-PURPOSE RADIOCHEMISTRY CELL

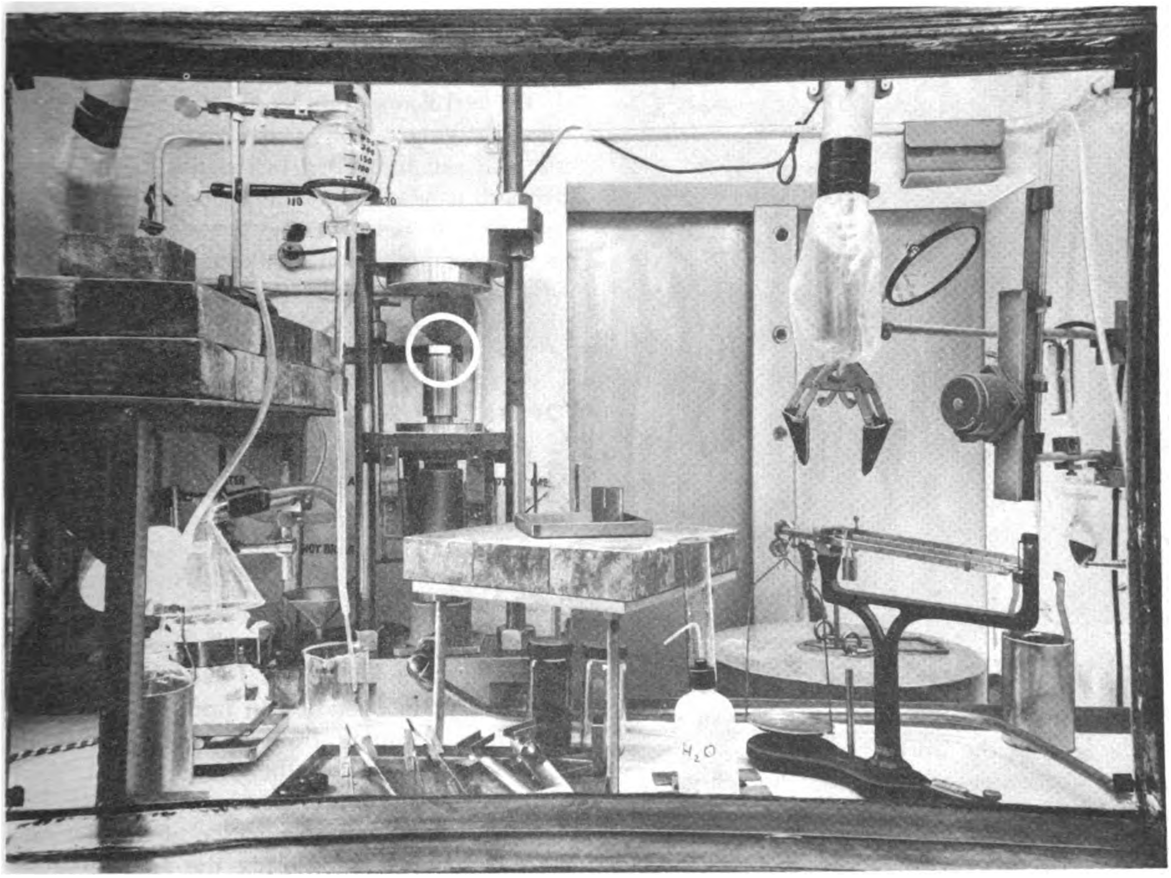


Fig. 1 Interior of cell as seen through viewing window.

APPLICATION

The radiochemistry cell is utilized to process radioactive materials for radiation sources. In the cell such operations as transferring active solutions or solids, measuring, weighing, sampling, threading capsules, soldering, and drilling can be performed by remote control to fabricate sources with strengths up to 1000 curies.

DESCRIPTION

The radiochemistry cell is a poured-concrete structure, the interior of which (Fig. 1) is 60 in. wide by 43 in. deep. The working surface inside the cell is 42 in. above the building floor, and the walls extend 51 in. above the working surface. The walls are 24 in. thick on the front and sides and 12 in. thick on the back. Scatter shielding is provided on top by means of 2-in.-thick lead bricks supported on a steel plate. Two 12½- by 14½-in. holes in this plate permit movement of the vertical arms of a pair of master-slave manipulators (Fig. 2).

A lead door, 4 ft by 2½ ft by 4 in. thick, is located in the back wall to admit shielded product carriers. Access to the cell for the addition of reagents or special tools is through a 12-in.-square by 8-in.-thick lead door. A tray on sliding runners moves materials from the doorway to the inside of the cell. Part of the working surface is recessed to a depth of 21 in. in order

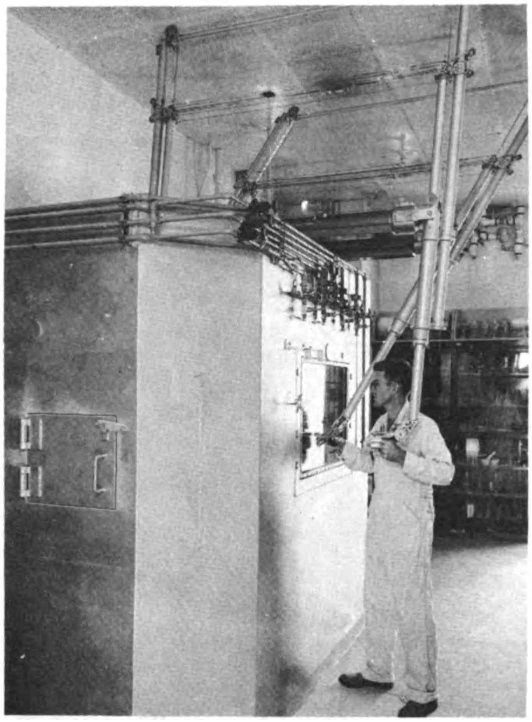


Fig. 2 Exterior view of radiochemistry cell.

that the top of the shielded carriers can be set at the level of the working surface.

Gas, air, water, vacuum, and hot off-gas are conveniently located inside the cell and are controlled by valves or extension handles grouped on the front face of the cell. In addition, 110-volt and 220-volt a-c receptacles are located inside the cell. A tool rack is located on the working surface to hold special tools which are easily grasped by the manipulator fingers.

The viewing window is 2 ft by 3 ft by 24 in. thick and is made of laminated glass, with the spaces between the glass filled with mineral oil. Additional vision is possible by periscopes inserted in the holes located in the front and side walls of the cell. Seven 200-watt incandescent bulbs give adequate interior lighting.

The working surface is covered with stainless-steel plate, which is extended to form a 4-in. flashing along the walls. Aluminum paint is used on the exterior walls and a white strippable coating is used on the interior walls of the cell.

The cell floors drain to the semihot waste system. Highly active wastes from processes in the cell can be routed to the hot drain system through a header extending above the working surface. A permanently installed floor spray aids decontamination of interior surfaces. Cell ventilation is provided through a 6-in. Transite duct with an adjustable damper.

OPERATION

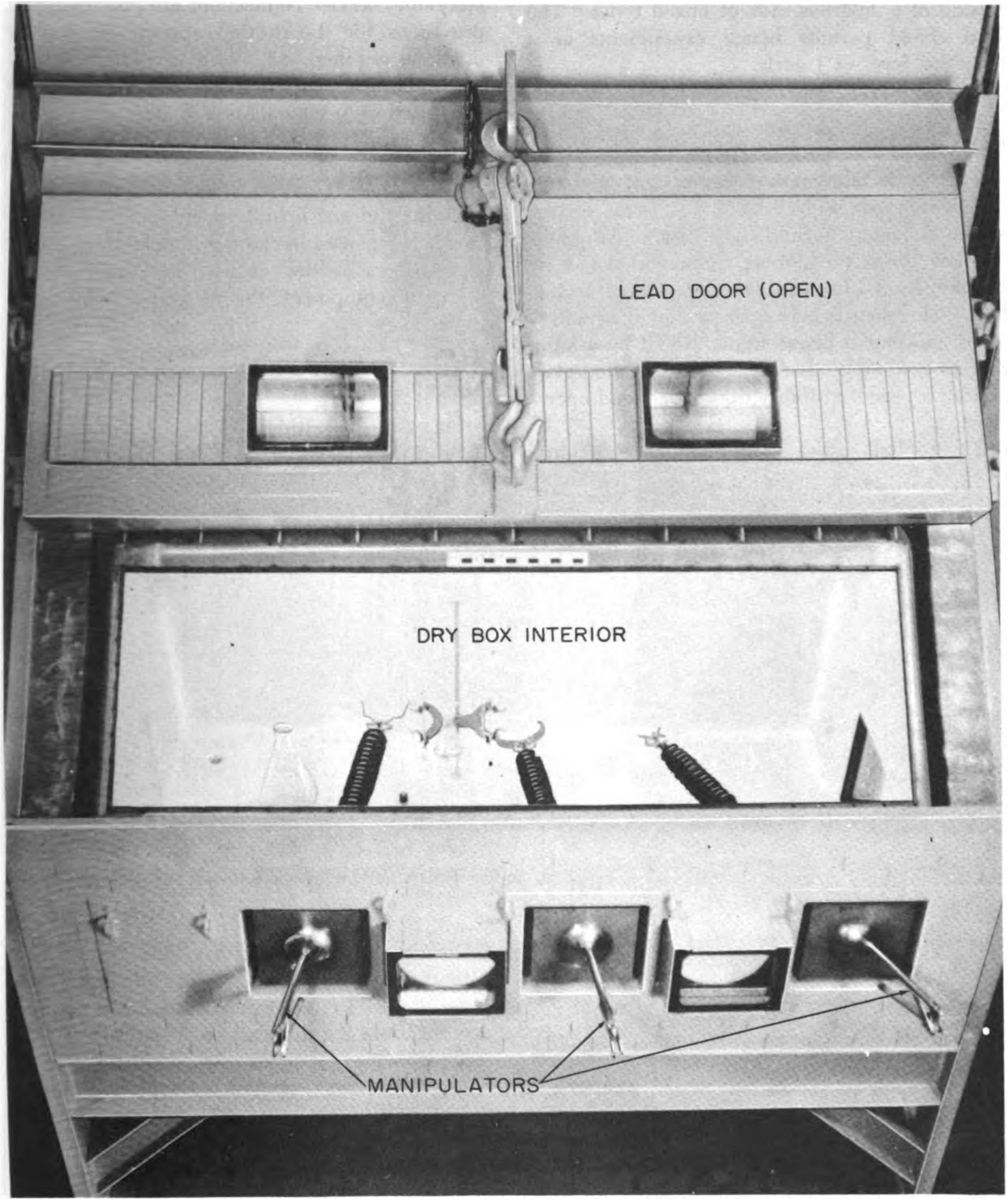
The preparation of a radioactive source involves the introduction and arrangement of the necessary equipment and reagents through the side access door and the introduction of the radioactive solution through the back door. The solution container is connected to the necessary supply lines for chemical processing by means of the manipulators. The ventilation system is kept in operation to prevent contamination from escaping from the cell, and liquid wastes are routed to the drains in the floor. After the source is fabricated and removed from the cell, partial decontamination of the cell may be necessary, such as using the floor spray or removing the strippable coating from the interior walls.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Document: E. E. Pierce, Operating a Manipulator Cell, *Nucleonics*, **12** (11), 86-87 (1954).

SHIELDED-MANIPULATOR DRY BOX



APPLICATION

This controlled-atmosphere shielded-manipulator dry box is designed for the handling and boxing of anhydrous salts of mixed types. The lead shield permits bench experiments at a radiation level of 1 curie.

DESCRIPTION

The box is fabricated of $\frac{3}{16}$-in. stainless steel and is approximately 3 by 3 ft in cross section and 6 ft long. A full-length safety plate-glass window forms the sloping front, and it can be covered by a 4-in. lead door for gamma protection. This door is held open or closed by safety stops, movement being accomplished by a 3-ton ratchet-type pull handle. Four leaded-glass windows permit visibility during shielded operations.

Three ball-swivel manipulators extending through the lower front wall provide the remote-handling facilities. Different-shaped heads on each facilitate a variety of operations. Normal laboratory service connections are provided, and provisions for the desired atmosphere can be made as required.

The box and its 4-in. lead-brick shielding are supported by a channel-iron frame.

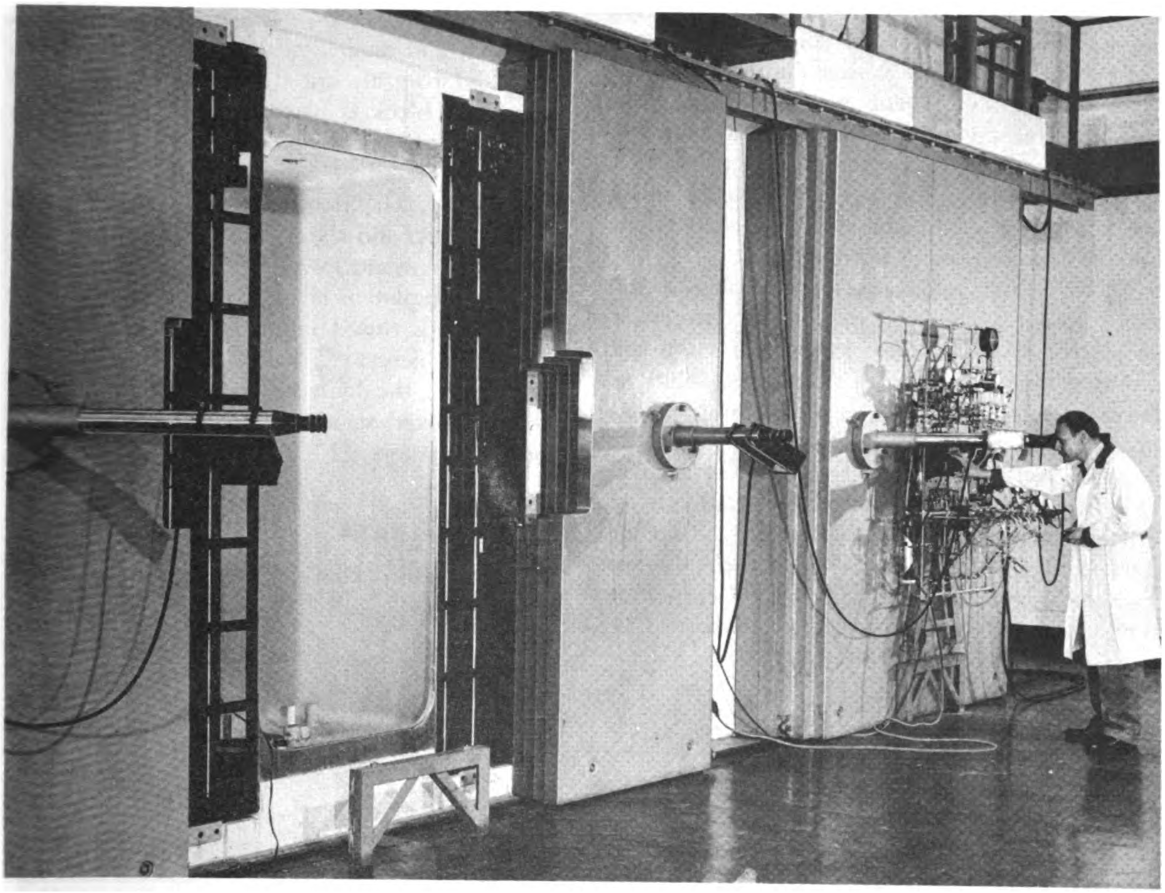
OPERATION

During normal operation, equipment and materials are placed in the box through the 10- by 12-in. doors located at each end. For larger pieces of equipment, the plate-glass window is removed.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: E-10451.

HOT CELLS



Viewing hot-cell interior. Open cell on the left shows construction details.

APPLICATION

These hot cells are utilized for the chemical processing, by remote control, of multicurie amounts of radioactive material. The cells were designed to handle 50 curies of a 2-Mev gamma-emitting material, but ordinarily accommodate considerably larger amounts. Processing equipment and control panels are mounted on a removable plug, permitting assembly and testing in an equipment assembly room. The cell is tied up only during actual hot runs, allowing for maximum utilization of the hot cell. Since personnel do not enter the hot cell, the size of the processing equipment is limited only by the interior dimensions of the cell. Different apparatus can be used consecutively, providing for a flexibility of operation difficult to achieve when equipment must be assembled inside the cell.

DESCRIPTION

The hot cell is a shielded cubicle 8 ft high, 4 ft wide, and 3 ft deep. The walls, roof, and floor are solid 3-ft-thick ordinary concrete. The cell interior is lined with $\frac{1}{8}$-in. stainless-steel plate, coated with blue Amercoat strippable paint. The front of the cell consists of two hydraulically actuated 11-ton solid steel doors 1 ft thick and 11 ft high.

The doors have stepped edges, preventing

straight-line penetration of radiation. A rectangular opening in the center of the closed doors is filled by a removable, self-supporting, steel-encased lead block. Mounted on the cell side of the block are a stainless-steel rack for supporting the remotely controlled process equipment and a stainless-steel diaphragm edged with an inflatable Tygon tube for sealing the cell from the operating area. Mounted on the outside of the block are the control panels. A series of straight and helical tubes in the block are used for tubing and electrical connections between the process and control racks.

There are four removable stepped plugs in the roof through which solid material is charged or removed. Two conduits in the rear of the cell are used for the transfer of active feed solutions between cells and the removal of samples and product solutions. Five waste drains in the floor are classified as to type of waste and level of activity. One drain serves additionally as an exhaust duct for cell-ventilation air. Two air intakes are provided near the top of the cell sides. Two periscopes mounted in the doors permit simultaneous observation of the cell interior.

OPERATION

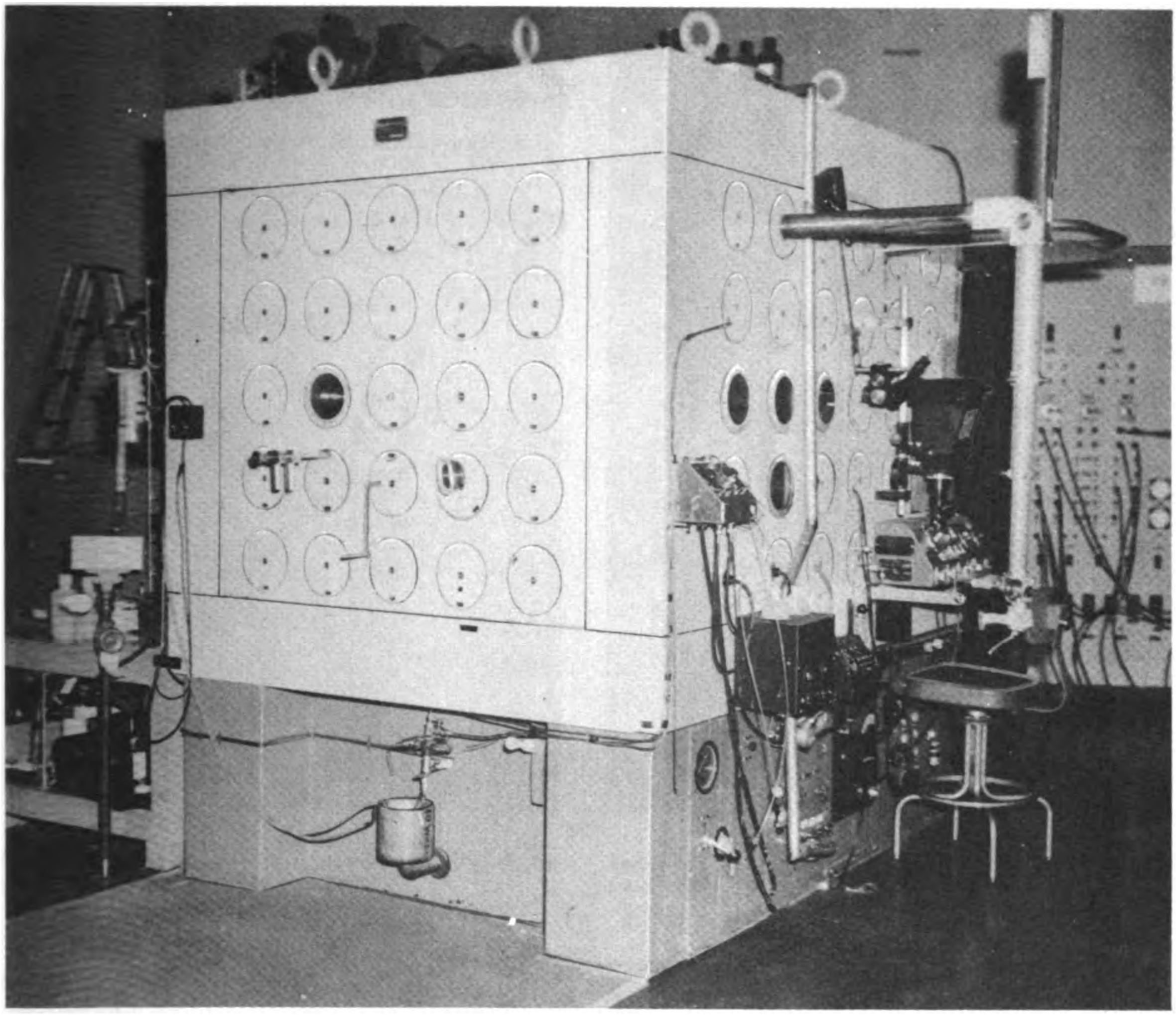
After assembly, the process equipment is put through a series of dummy runs, using cold chemicals or tracers. The assembly is then moved to the cell by a remote-controlled fork lift truck and an overhead crane. All connections and controls are thoroughly checked out before the block is placed in its final position. Lines going to the drains are mounted on a bar, which is lowered pneumatically well within the cell drains. The doors are closed around the central block, and the Tygon tubes on the sealing diaphragm are inflated.

Upon completion of an experimental run, the equipment is rinsed internally and sprayed externally, if necessary, to remove gross activity. After drying, the doors are opened and the equipment is moved to a clean-up room for further decontamination.

REFERENCE DATA

Location: Brookhaven National Laboratory.

MULTICURIE CELLS USED IN RADIOMETALLURGY



APPLICATION

The multicurie cells provide a permanent source of radiation shielding in which the examination and metallurgical evaluation of irradiated materials can be performed without exposing the research technician to hazardous levels of radiation. Physical and mechanical testing and metallographic sample preparation and observation can be carried out as required through the use of remotely controlled equipment installed in the cells.

DESCRIPTION

The multicurie cell is made of Meehanite cast iron (density 7.0 g/cm^3) of uniform thickness in order to provide equivalent shielding on the sides, ends, top, and bottom. The 100-curie cells have 10½-in.-thick walls, and the 2000-curie cell has 15½-in.-thick walls. There are 140 access holes with a minimum diameter of 7¼ in. spaced symmetrically about the sides, end, and top. The single hole in the base is the air-exhaust duct hole. Steel plugs with retaining rings are used to close the access holes. In addition, special

cell plugs are available for viewing and for providing electrical, gas, or liquid outlets in the cell where required. The enclosed cell space is 72 by 52 in. and 49 in. high. The cells are designed with stepped joints to prevent radiation leaks. The walls and top may be removed for decontamination or to install or remove equipment.

OPERATION

Equipment less than $7\frac{1}{2}$ in. in diameter is placed in the cell through a cell plug hole, and larger equipment is installed through the removable ends. The equipment controls are brought outside the cell through special cell plugs. Sample manipulation is carried out by the use of the Hanford slave manipulators.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Drawings: H-4-50146, H-4-50147, H-4-50148, H-4-50149, H-4-50160, H-4-50161.

SHIELDED HOOD ANL MODEL 1

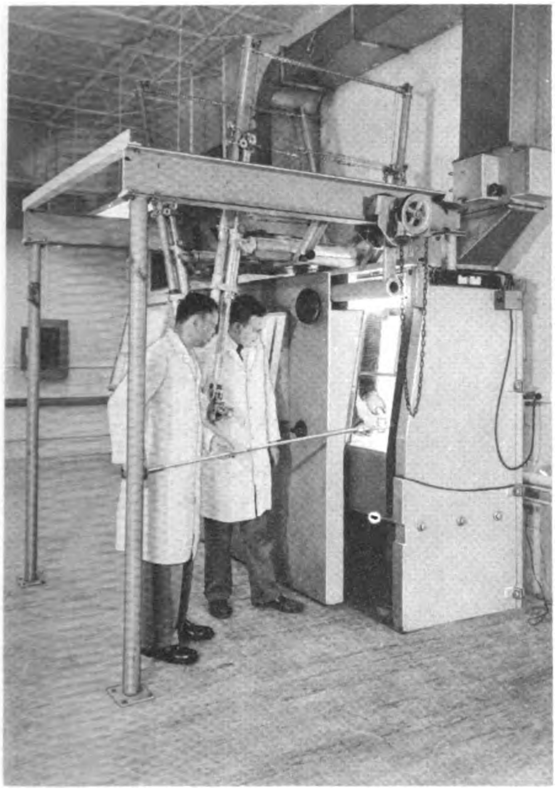


Fig. 1 Shielded hood with front wall rolled aside for limited access during experiment.

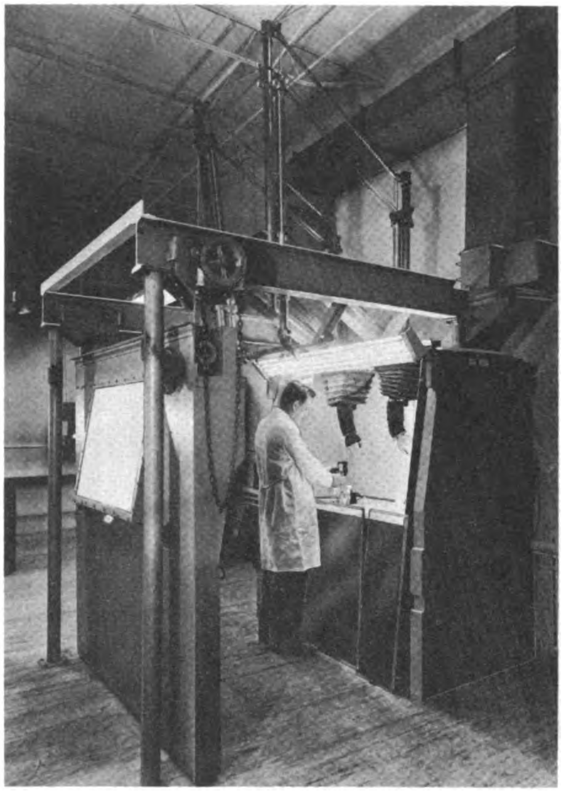


Fig. 2 Complete access for setting up is afforded with front wall rolled out.

APPLICATION

This installation (Fig. 1) provides a hood with sufficient gamma shielding to permit work with as much as 0.2 curie of cobalt 60 radiation. Most of the convenience of ordinary hood operation is retained by the provision of master-slave manipulators and an unusual arrangement of the front shielding.

DESCRIPTION

The working volume, 52 in. high by 59 in. wide by 28 in. deep, is surrounded by 3 in. of steel equivalent on the four sides. The front consists largely of a 26 by 33 by 9 in.-thick lime-glass window made up of nine plies of 1-in. plate. The shielding extends down to the floor so that the space below bench height may be used for equipment such as waste containers. The top of the hood is unshielded. Two plugged access holes are situated at the lower corners of the window, so that specimen material may be easily inserted.

The sheet-metal inner hood is semisealed against the spread of contamination, the manipulators are connected with rubber bellows to the hood, and sliding doors and panels cover the working face. Air ventilation of 200 to 300 cfm flows from left to right between plenum chambers that comprise most of the end walls. Filters are provided on both the incoming and outgoing air ducts.

OPERATION

The entire front wall is carried by rollers on a transverse tubular beam so that it can be rolled sideways some 19 in., providing limited access. For complete access the tubular beam (Fig. 2) is moved out on the I-beam structure. For the latter operation, the manipulators are tilted up as shown, requiring an 11-ft minimum ceiling height.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: R. A. Blomgren, Shielded Hood Model 1, ANL-4964, January, 1953.

Reference Drawing: RCD-98.

MOBILE SHIELD

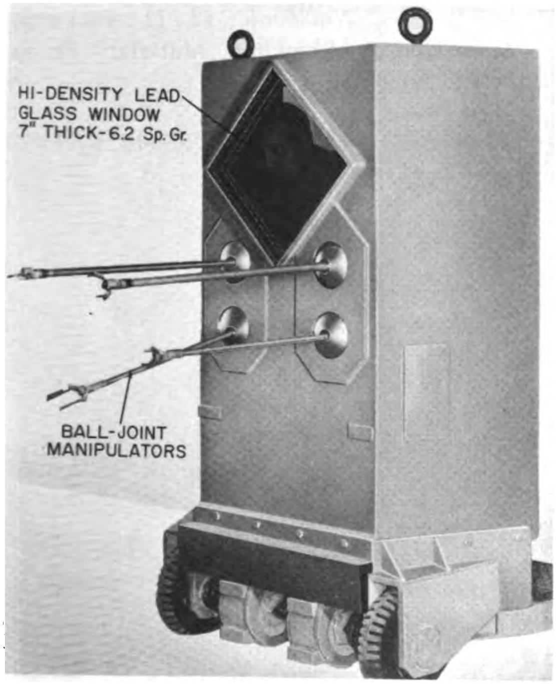


Fig. 1 Front view of mobile shield.

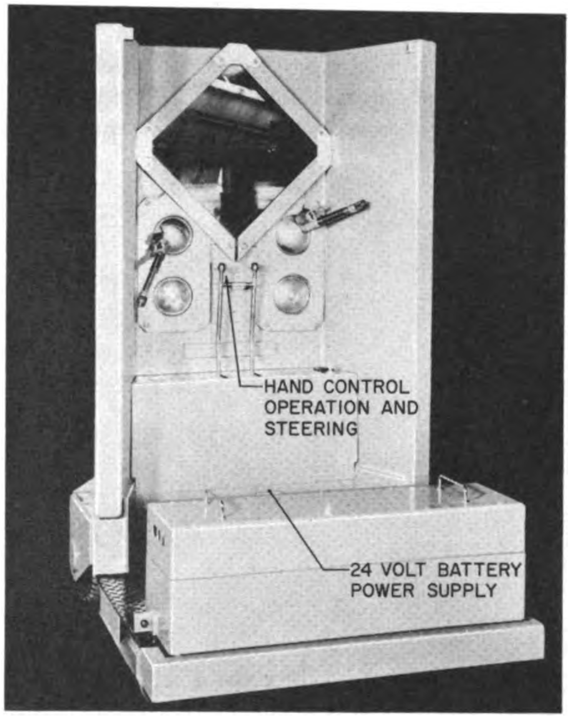


Fig. 2 Back view of mobile shield.

APPLICATION

This 4-in.-thick lead personnel shield, sheathed with stainless steel, is used for simple remote handling using ball-joint manipulators to remove targets from a cyclotron. The unit performs satisfactorily on a 3° incline and for 8 hr of continuous service. Master-slave manipulators for more intricate operations could be added if desired.

DESCRIPTION

The unit is 47 in. wide, 58 in. long, and 81 in. high and weighs 10,000 lb. The shield is mounted on a battery-powered chassis with a single hand control for steering and forward and reverse fine-speed control. A single 24-volt d-c motor develops 3.3 hp and drives the two front wheels independently through two hydraulic transmissions. Full speed, 90 fpm on a level floor, draws 60 to 70 amp from the batteries. The center of gravity of the unit is 9 in. behind the front-drive-wheel center line and 36 in. above the floor, permitting safe braking at full speed.

The 8-in.-diameter brass balls for the manipulators are cast in an inexpensive high-density shielding material. The manipulators have handles adjustable along the rod, and the tong jaws can be oriented within 45° of parallel to the axis of the main rod. The tong head is removable but is locked mechanically to the rod when in use.

OPERATION

With the transmission in neutral, the left- or right-hand control (Fig. 2) is pushed down to start the motor. The speed-control valves on the transmissions can be engaged only by so depressing the control handles; releasing the handles returns the valves to zero and shuts off the motor.

One hand can control both drive wheels independently for steering. The shield pivots on either wheel as a center by moving the opposite hand lever in the direction of desired turning. The shield will go forward or backward by pushing both handles forward or backward. Driving the wheels in opposite directions at approximately the same speed rotates the shield about the center of the shielding wall. There is good speed control from 0 to 25 rpm for each drive wheel.

REFERENCE DATA

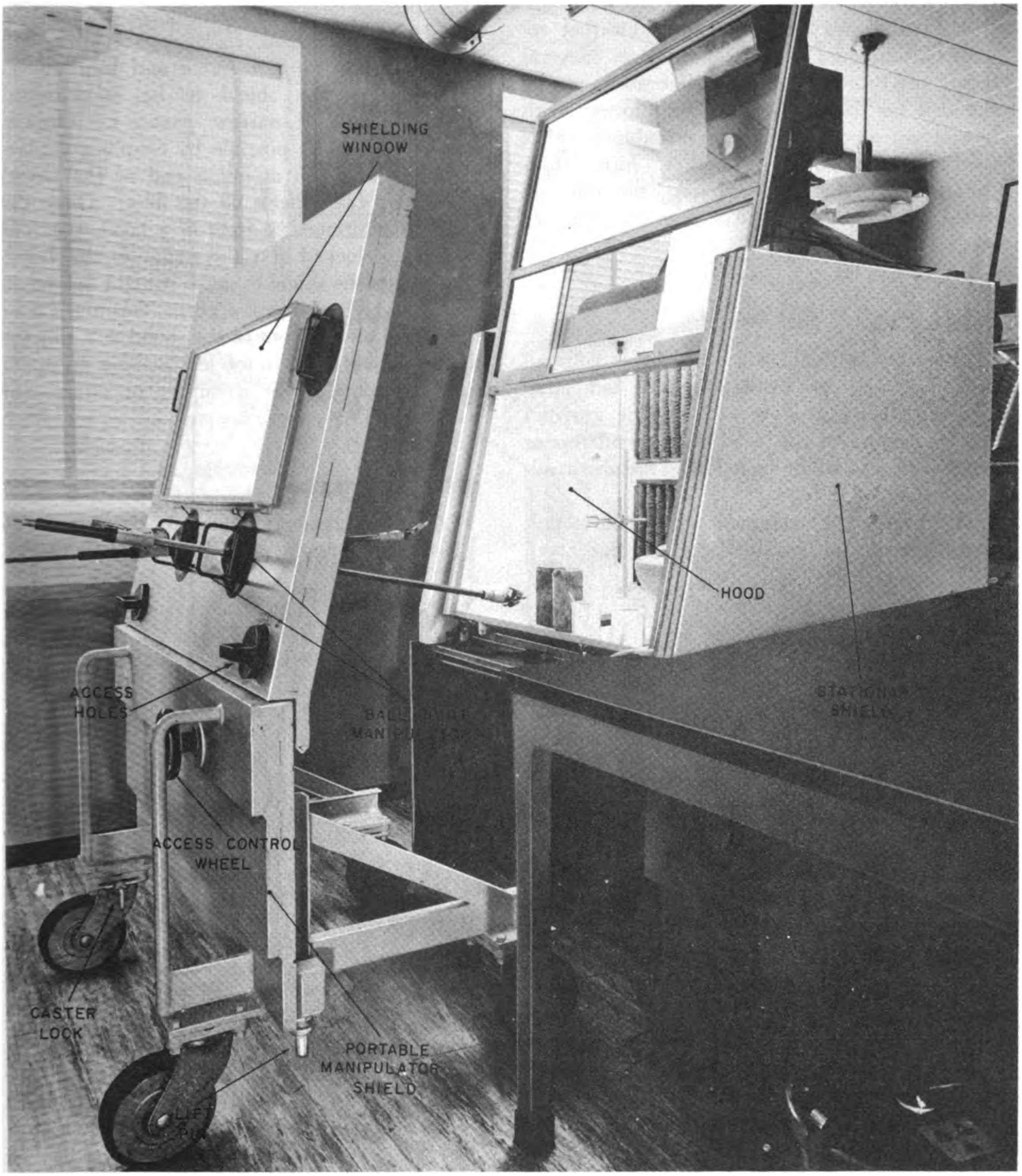
Location: Argonne National Laboratory.

Reference Documents: R. A. Blomgren and N. J. G. Bohlin, Mobile Shield for Cyclotron Target Removal, *Nucleonics,* **12** (11), 62 (1954).

High Density Shielding Material, *Product Eng.*, August, 1954, p. 195.

Reference Drawing: Mobile Shield, RCD-378.

PORTABLE SHIELDING FOR CHEMISTRY HOOD



Hood with portable shield rolled away.

APPLICATION

Designed for the occasional handling of fractional curie quantities of radioactive materials, this shield forms an economical unit that requires a minimum of laboratory space. Several hoods, used intermittently for hot work, can be shielded on the sides, back, and bottom with inexpensive steel plates. The portable shield is then rolled from one to the other. Moved to a storage area when not required, the portable shield leaves the hoods available for ordinary use.

DESCRIPTION

The portable shield is a 3-in.-thick steel wall with a 16- by 29- by $4\frac{1}{2}$-in.-thick laminated x-ray lead-glass window (4.7 specific gravity) and four portholes for ball-joint manipulators or access. Two smaller plugged holes are also available for access.

Three inches of steel, made up of 1-in. plates, forms the stationary shielding for the hood. These plates are flame-cut, stacked in position, and clamped.

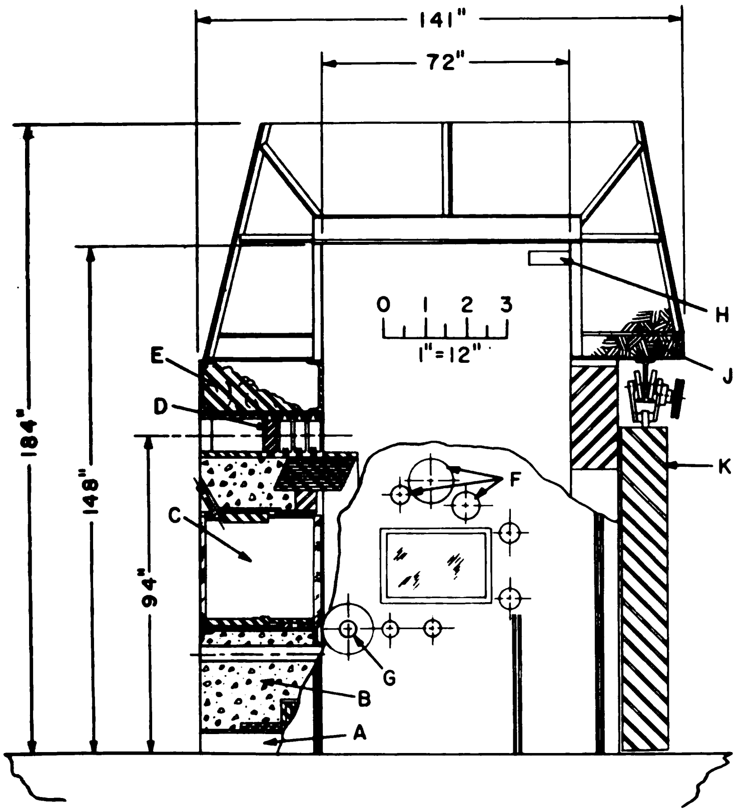
OPERATION

A U-shaped support frame and four swivel casters allow the shield to be maneuvered through doors or narrow passages. Greater maneuverability is possible by coupling a portable jack to a pin at either end of the shield and lifting two wheels off the floor. Once the shield is positioned in front of a hood, the four wheels are locked at right angles to the hood. This causes the shield to move straight out when pulled away for general access. Turning a control wheel on the front of the shield will roll the upper section 14 in. to the left, making an opening large enough for a sample or equipment transfer.

REFERENCE DATA

Location: Argonne National Laboratory.
Reference Drawings: RCD-222 and RCD-250.

METALLURGY CAVE ANL MODEL 4



A–VENTILATION OR UTILITY INLET

B–MAGNETITE CONCRETE

C–ZINC BROMIDE WINDOW

D–MANIPULATOR SLOT

E–STEEL PUNCHINGS AND MAGNETITE ORE

F–OPTICAL PORTS

G–TRANSFER PORT

H–VENTILATION EXHAUST PORT

J–LOOSE MAGNETITE ORE

K–ACCESS DOOR

Fig. 1 Right side of cave with cutaway section.

APPLICATION

This cave was designed primarily to accommodate machining operations and physical-properties measurements. Because it is not tightly sealed, experiments must be planned to minimize the contamination hazard. Excellent vision is provided, and the access doors are large enough to ease the problems of frequent changes in experimental equipment.

The cave can accommodate 10,000 to 30,000 curies of 1-Mev gamma activity under normal continuous operation provided that supplementary window units are used to develop the full shielding power of the walls. With the windows as shown, the corresponding limit is 200 to 500 curies.

DESCRIPTION

The inside dimensions (Fig. 1) are 6 ft deep, 10 ft wide, and 12.5 ft high. The total weight of the cave as shown is 210 tons. The cave is lined with steel and finished with a strippable paint and industrial adhesive tape.

There are two 36- by 30-in. zinc bromide solution windows (*C*, Fig. 1) at the front and 30- by 20-in. observation windows at either side. Fourteen sodium-vapor lamps are placed around the inside frame of the front window. Auxiliary fluorescent lighting is also provided.

About 300 cfm of ventilation is provided, with exhaust prefilters situated in each of the rear corners of the cave. Final paper filters are immediately outside the cave.

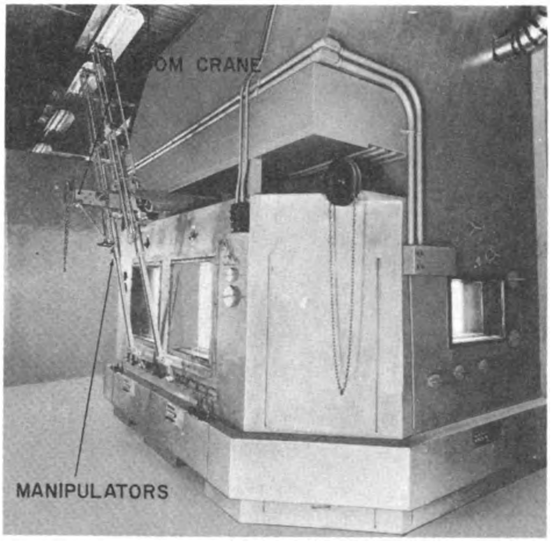


Fig. 2 Metallurgy cave and manipulators.

The cave uses two model 6A master-slave manipulators. An electrically controlled indexing feature allows the slave end to extend and retract a distance of 24 in. A 1000-lb capacity boom crane mounted between the manipulators (Fig. 2) on the same carriage can traverse the width of the cave. This crane is often used to remove plugs from lead-filled containers.

OPERATION

The cave design has been adaptable to a great variety of equipment setups over the past three years. The need to decontaminate each piece of equipment has led to the erection of an isolation room behind the cave proper.

The superior model 8 manipulator has since been designed and would be used instead of the model 6 if the facility were duplicated.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: E. W. Rylander and R. A. Blomgren, Operating Procedures of a Hot Laboratory for Solid-state Tests, *Nucleonics*, **12** (11), 98–100 (1954).

Reference Drawings: Model 4 cave, RCD-232; model 3 cave, RCD-180; Manipulators, RCD-130.

INTERMEDIATE-LEVEL TRIPLE-CELL CAVE

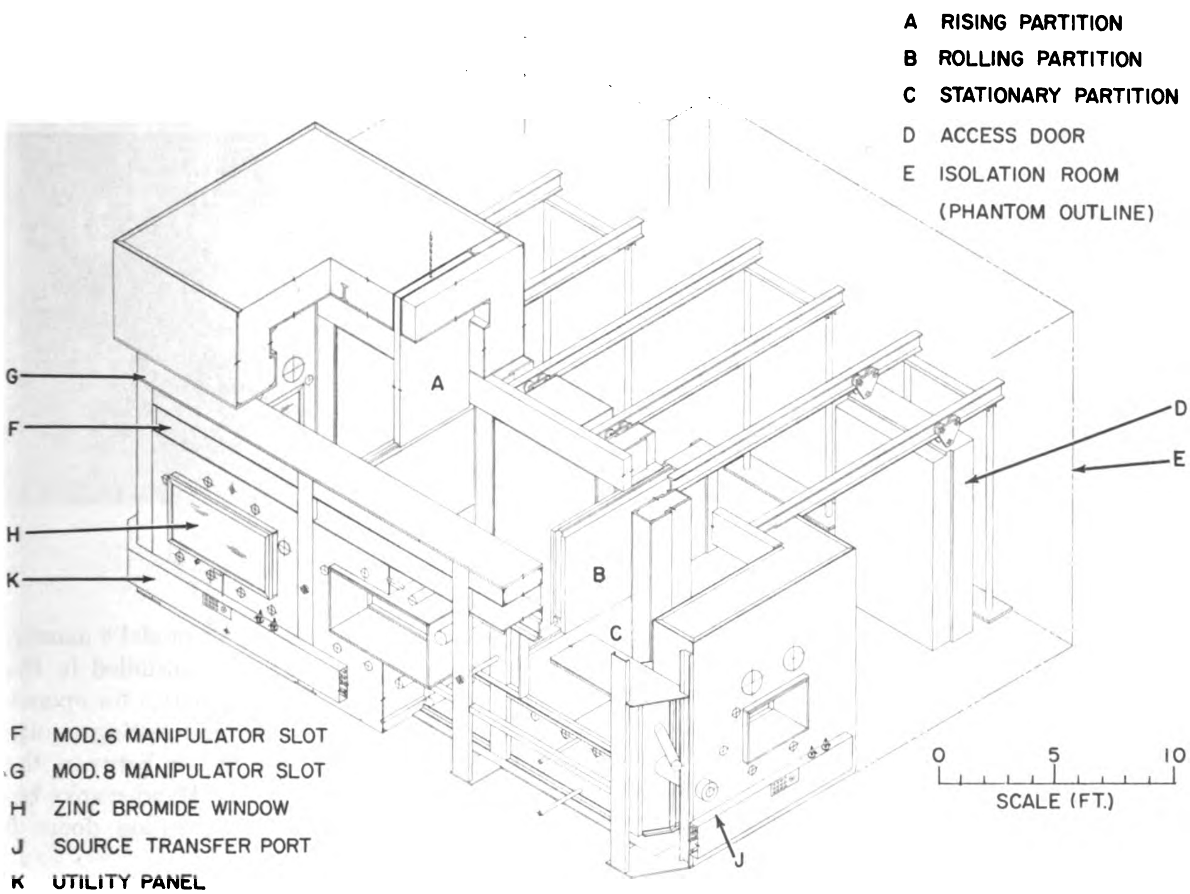


Fig. 1 Structural cutaway of triple-cell cave. *A*, rising partition; *B*, rolling partition; *C*, stationary partition; *D*, access door; *E*, isolation room (phantom outline); *F*, model 6 manipulator slot; *G*, model 8 manipulator slot; *H*, zinc bromide window; *J*, source transfer port; *K*, utility panel.

APPLICATION

This cave was designed to house a metallographic production line. The equipment is arranged according to the order of operations and is rarely removed to accommodate other experimental equipment. Three cells are provided so that the contamination resulting from grinding and polishing can be localized. A small conveyor belt running the length of the cave transfers specimens with a minimum risk of contamination spread.

DESCRIPTION

Designed to shield 100 curies of 1-Mev gamma radiation, the cave has 2-ft-thick concrete walls of 3.2 specific gravity. Cave walls above 8 ft and access doors are welded steel boxes filled with loose magnetite ore. Steel punchings have been added in locations requiring higher density shielding.

Each cell interior is 7 ft wide, 6 ft deep, and 12.5 ft high, with 8-in.-thick steel partitions between cells. Section *A* (Fig. 1) can be raised

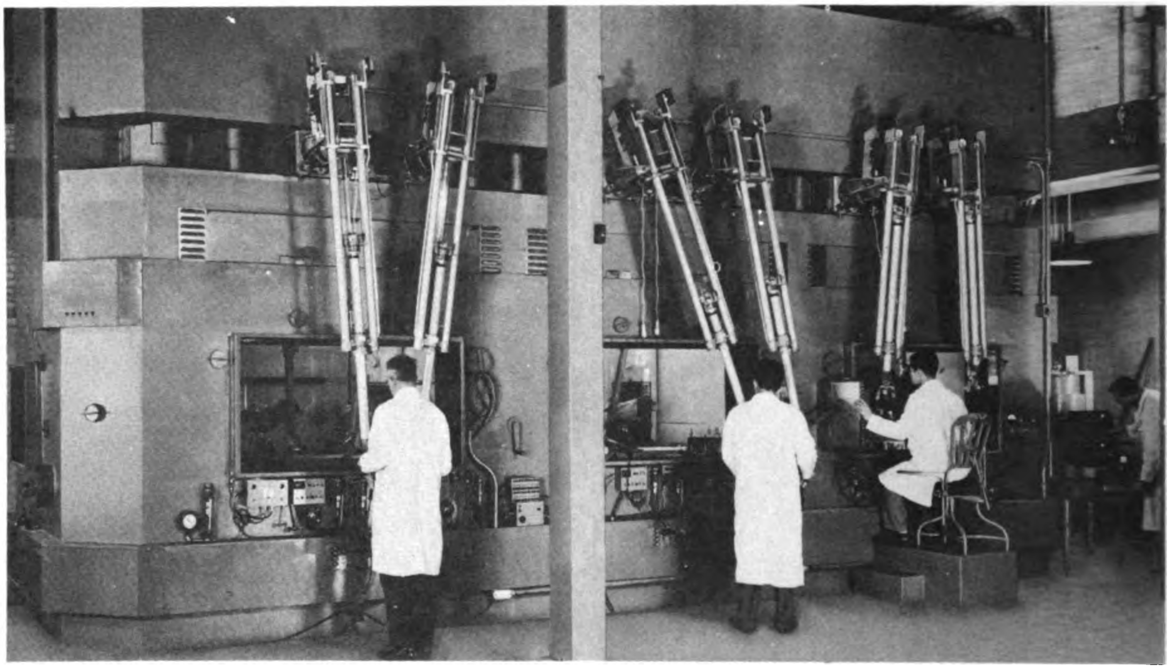


Fig. 2 Triple-cell cave in operation.

8 to 12.5 ft to allow passage of manipulators or a crane traveling on the channel rails. The partition (*B*) from the 4- to 8-ft level rolls back. The access doors (*D*) roll away from the cave to provide 5-ft-wide by 8-ft-high openings.

Two slots (*F* and *G*) were provided with accordion-type scatter shields, adaptable to either slot. The window frames are an integral part of the steel structure and are not removable. The windows are 30 in. high, 58 in. wide, and 28 in. thick with glass cover plates to form a tank for zinc bromide solution.

The ventilation system is balanced to exhaust approximately 600 cfm from the highest contaminating cell (grinding), with proportionately less exhausted from the other cells. This allows flow of air between opened partitions to the most dirty cell to minimize cross contamination during transfers.

OPERATION

The cave (Fig. 2) uses the six model 8 master-slave manipulators (page 123) installed in the upper slot. Remote-control actuators for operating the grinding, polishing, and testing equipment are mounted in the recess between the window and the utility panel. Hand cranks between the windows operate partition doors *B* (Fig. 1).

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: E. W. Rylander and R. A. Blomgren, Operating Procedures of a Hot Laboratory for Solid-state Tests, *Nucleonics*, 12 (11), 98 (1954).

Reference Drawings: Cave, RCD-380; Manipulator, RCD-371.

JUNIOR CAVE ANL MODEL 1

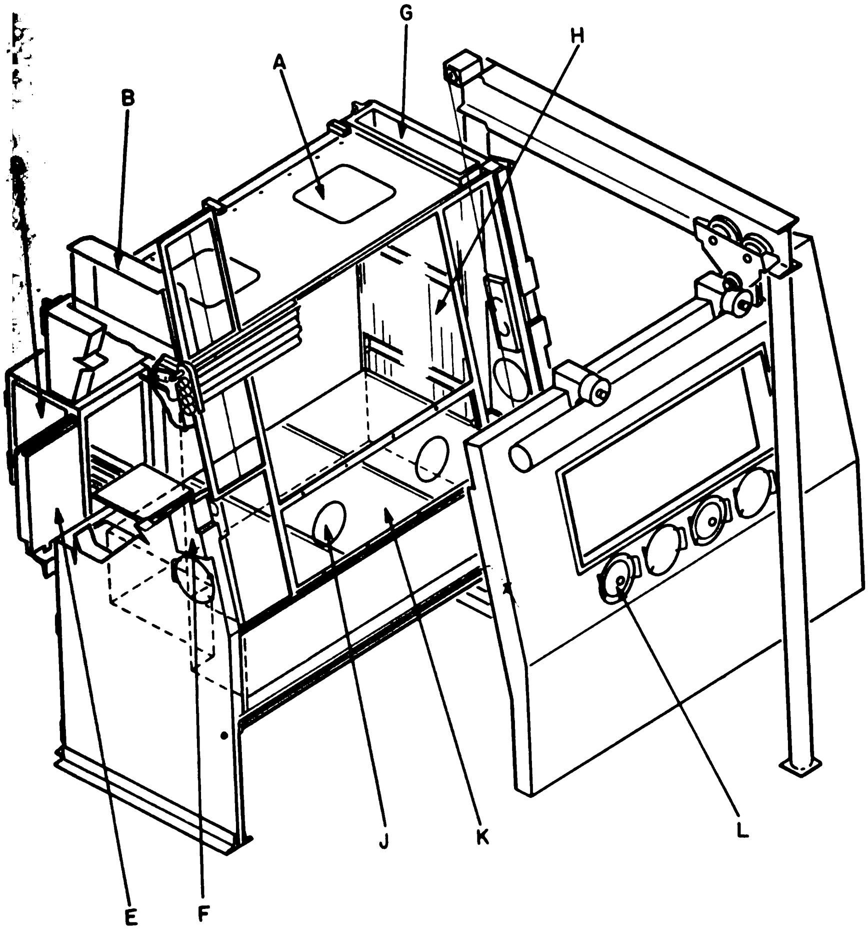


Fig. 1 Cutaway view of junior cave. *A*, master-slave manipulator port; *B*, air inlet; *C*, lighting; *D*, hinged door; *E*, sliding door; *F*, utility access; *G*, exhaust duct connection; *H*, prefilter (inside); *J*, glove port; *K*, removable tray (inside); *L*, manipulator ports.

APPLICATION

This junior cave model 1 shielded enclosure is primarily useful for low-level chemistry research. Provision is made to use ball-joint or model 7 master-slave manipulators (see page 125) or both. A contamination barrier behind the movable gamma shield maintains ventilation even when the gamma shield is open. A transfer chamber at the back permits the introduction of reagents or small equipment during an experiment.

DESCRIPTION

The interior of the hood is 30 in. deep, 60 in. wide, and 41 in. high. The access doors on each side at the front provide a 10-in.-wide by 20-in.-high opening. The transfer chamber at the rear will handle an object 9 in. square by 12 in. high. The window in the movable gamma shield is 20-in.-high, 40-in.-wide, and 4½-in.-thick lead glass. The shielding is equivalent to 3 in. of steel on all sides except the transfer chamber, which is only 2 in. of steel.

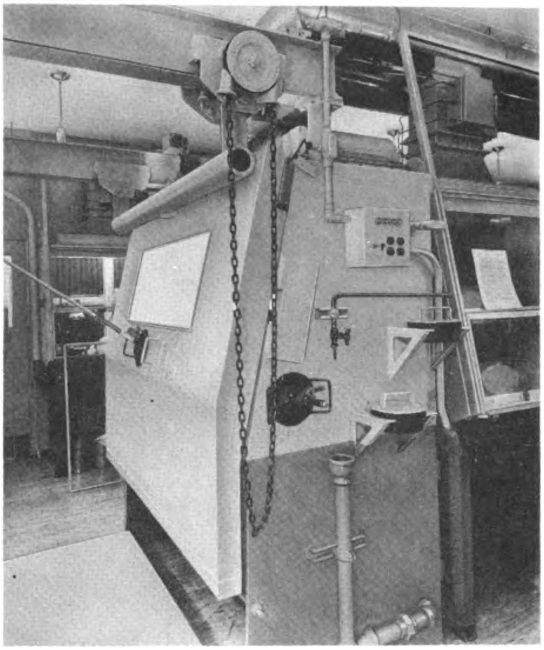


Fig. 2 Junior cave with gamma shield in place.

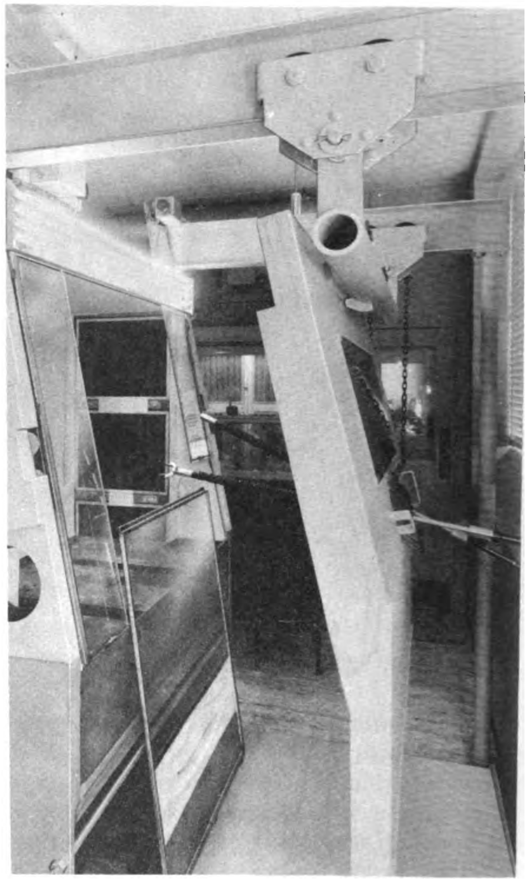


Fig. 3 Gamma shield moved out for access to cave.

The 300-cfm ventilation is cross flow from left to right with prefilters (Fig. 1) inside the hood.

OPERATION

The ball-joint manipulators penetrate the center lower panel through a rubber diaphragm (Fig. 3). The front gamma shield can move to either side to allow access through the front doors. It can also be moved back on the overhead I beams to allow complete access to the ventilated enclosure. The transfer chamber at the rear has a telescoping tray to bring material into the hood.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Cave RCD-281; Ball Joint Manipulators RCD-376.

CHEMISTRY CAVE

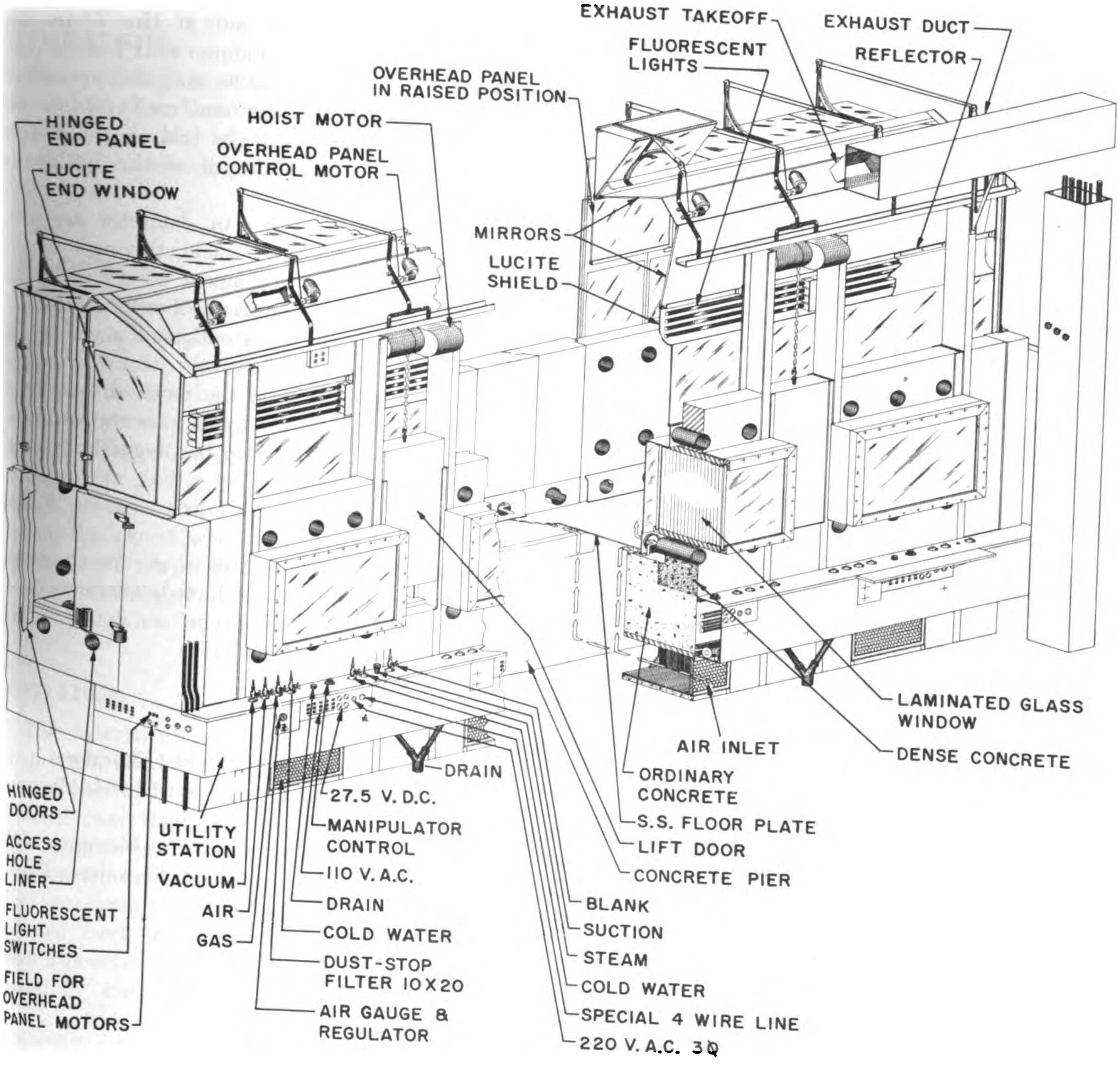


Fig. 1 Chemistry cave showing structural details.

APPLICATION

This chemistry cave was prepared to house a particularly complicated chemical-extraction procedure. It permits easy access for setup and alteration of such process equipment.

DESCRIPTION

As seen in Figs. 1 and 2, the cave is a trough-like shield with inside dimensions of about 3 ft wide by 3.5 ft deep by 18.5 ft long. The base pedestal of ordinary concrete is hollow and is

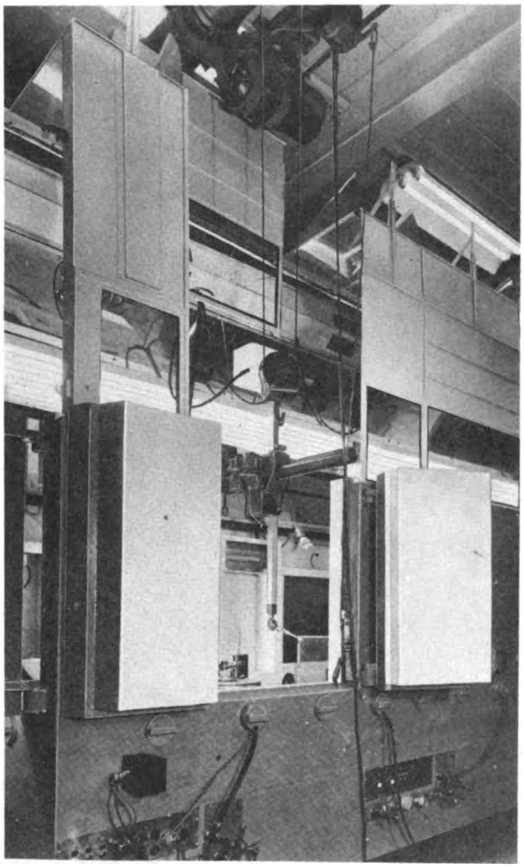


Fig. 2 View through open rear door, showing retracted roof panel and electrical manipulator.

used primarily as an intake-air plenum chamber. The shielding above bench height is 6 in. of steel, laminated of 1-in. plate to permit labyrinth construction at the many door openings. Along the sides and back, six pairs of hinged doors permit 30-in.-wide openings, with 24-in. mullions between. Four laminated plate-glass windows along the front wall are separated by 12-in.-wide lift doors.

The gamma shielding ends at the 78-in. elevation, giving way to aluminum and Lucite panels which control ventilation and the spread of contamination. The rear and roof panels are hinged so that they may be folded completely out of the way and allow use of the building's overhead crane.

Many access holes of 4 in. diameter are provided through the fixed shield, through which fluid, electrical, or mechanical lines may pass. A utilities strip surrounds the base pedestal at knee height and provides outlets of a variety of services at convenient intervals.

The manipulator is of the motor-driven type and is controlled from any of nine stations into which the control box may be plugged.

OPERATION

Although the cave is still in use for chemical experiments, they are conducted, whenever possible, with master-slave-type manipulators in shielded hoods or junior caves.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Cave, RCD-34; Manipulator, RCD-72.

Reference Document: R. A. Blomgren and French Hageman, Improved Chemistry Cave, ANL-4426, Mar. 1, 1950.

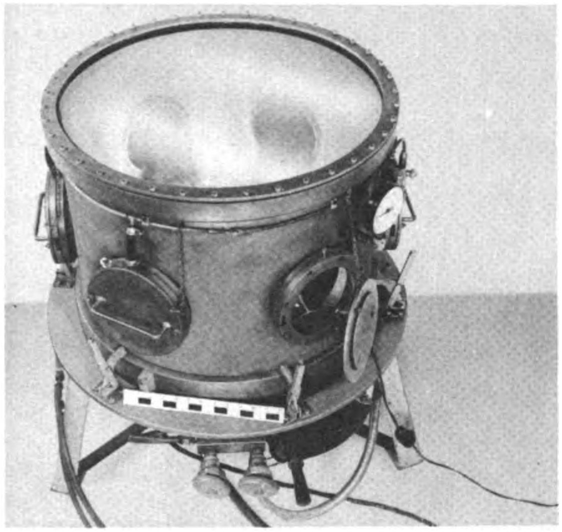
CONTROLLED-ATMOSPHERE WELDING CHAMBER

APPLICATION

This welding chamber is designed to facilitate the welding or brazing of materials which are especially prone to oxidation. Oxidation is prevented by surrounding the material with an inert gas.

DESCRIPTION

The chamber consists of a 24-in.-ID cylinder 18 in. high clamped to a base plate having a support frame mounted on casters. It is equipped with a 1-in.-thick transparent plastic cover for viewing and six gloved ports for operating access. The gloved ports are equipped with covers and a pressure-equalizing system which prevents atmospheric pressure from rupturing the gloves when the air in the chamber is evacuated. A pressure-vacuum gauge, a pressure-relief valve, and electrical leads are also provided.



OPERATION

The material to be welded, filler wire, a 40-amp torch, and other necessary equipment are placed on the base plate, and the chamber is lowered over them and clamped down. The glove-port covers are secured, and the chamber is evacuated to about 28 in. vacuum. The pressure-equalizing lines to the gloves are then shut off, and inert gas is admitted to the chamber until a positive pressure of about 2 psi, determined by the setting of the relief valve, is reached. Welding or brazing is then started. During operation, inert gas is purged continuously through the chamber to carry off the gases evolved in the welding operation.

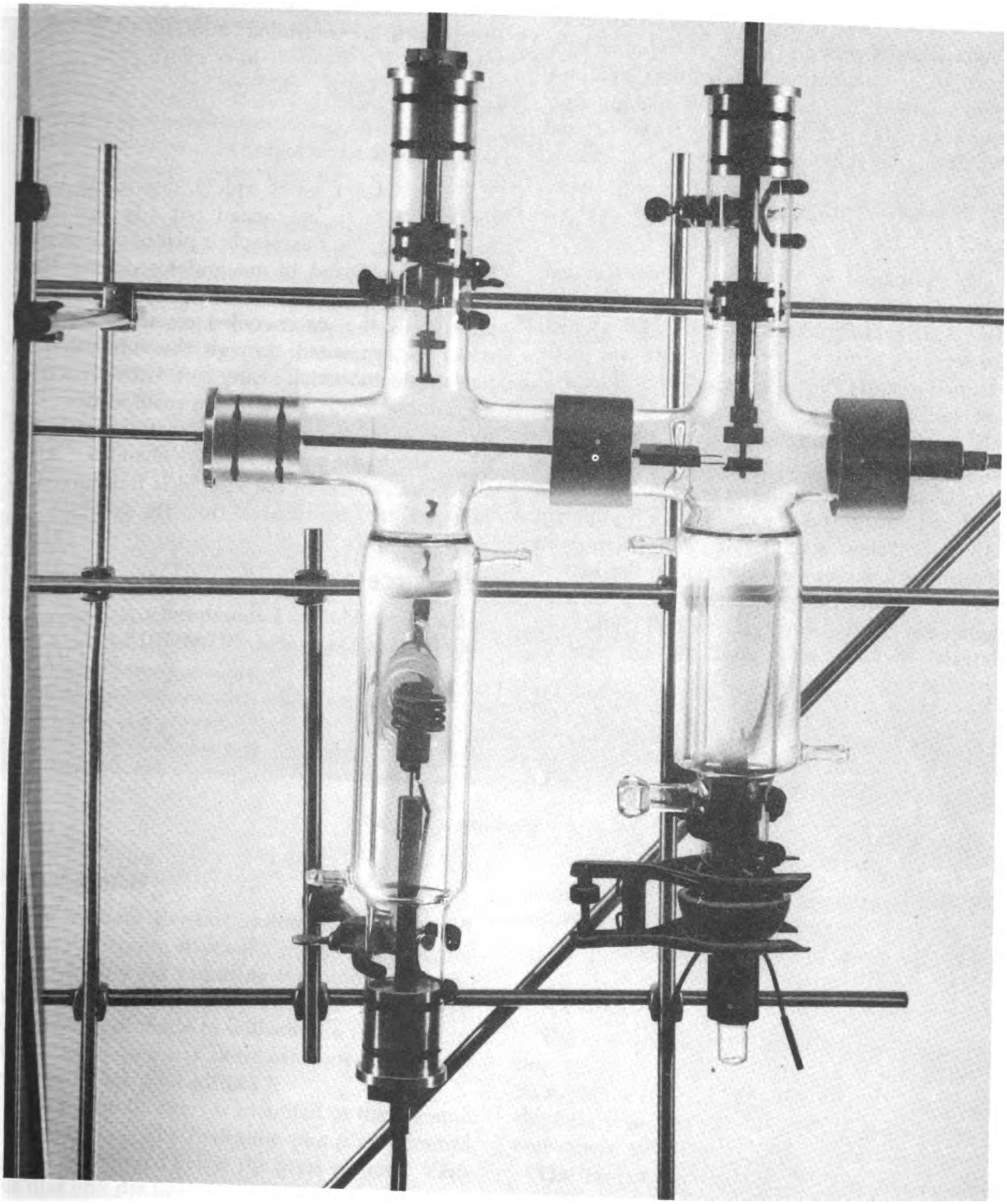
The operations required to set up the chamber take about 1 hr.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawing: D-13284.

CONTROLLED-ATMOSPHERE ENCLOSURE CHAMBER



View of a typical setup.

APPLICATION

The controlled-atmosphere enclosure chamber, referred to as a *Fox-T*, is essentially a principle for designing apparatus for performing operations in a vacuum or a controlled atmosphere. It automatically provides a barrier to prevent the spread of contamination. It features small reaction volumes, the use of simple manipulators requiring only translation and rotation, and adaptability to remote control.

DESCRIPTION

The equipment, as illustrated, consists of one or more interconnected complex tees. Manipulators *A*, *D*, and *J* pass through plugs (*B*), which also serve as bearings. Vacuum seals are made with neoprene O rings. Manipulators *A* and *D* have special carriers which can be mounted on rods concentric to the manipulator rods to permit independent translation and rotation. Pistons (*C*) are used to seal the reaction chambers, which comprise the lower arms. Equipment within a reaction chamber is mounted on suitable supports on, or passed through, the bottom closures. Arms may be closed with internal plugs (*B*), external caps (*E*), or ball joints (*G*). Material may be introduced through arm *E*, through an additional arm, or by removing one of the arm closures. A third tee can be joined to arm *E* for more complex operations. Gas can be circulated through tubulations such as *H* and *I*, and the entire system can be evacuated and filled with a controlled atmosphere through tubulation *F*. Reagent lines can be introduced through the bottom closures.

OPERATION

The operation varies widely, depending upon the processes to be carried out. In the illustrated apparatus, the sample is placed on manipulator *J*, transferred to manipulator *A*, and then lowered into the induction furnace. This operation seals the water-cooled reaction chamber, which is evacuated through the tubulation in back of the induction-heater coil. After reaction, the sample is transferred from manipulator *A* to manipulator *J* to manipulator *D*, after which it is lowered into the second reaction chamber. After the second reaction, the sample is transferred to manipulator *J* for removal from the system.

REFERENCE DATA

Location: Mound Laboratory.
Reference Document: MLM-1015.

VACUUM DRY BOX AND 50-TON PRESS

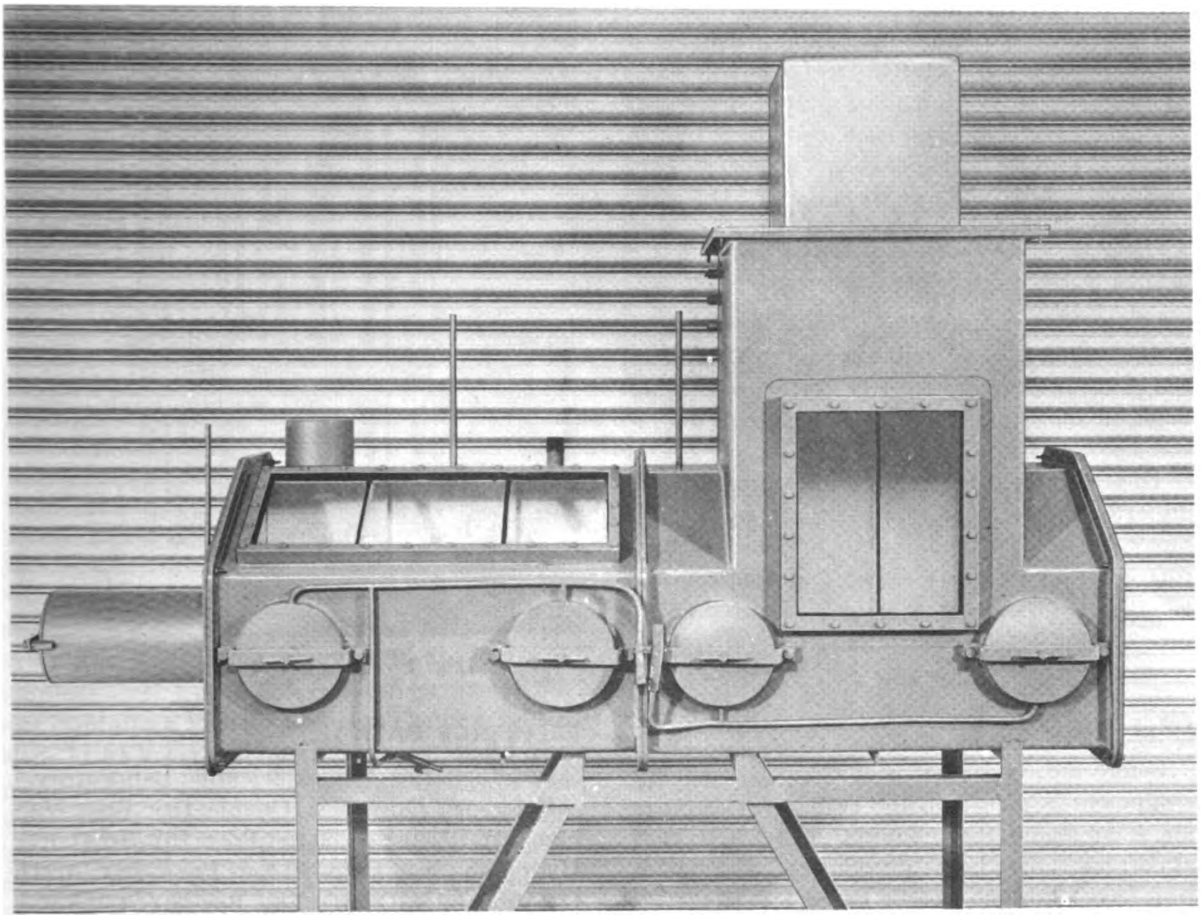


Fig. 1 Vacuum dry-box assembly.

APPLICATION

The vacuum dry-box system, including a 50-ton double-acting hydraulic press, was designed for research work requiring the preparation and handling of material in an inert atmosphere. The boxes are made to withstand a full vacuum. After the system has been evacuated, any inert gas can be introduced into it.

The hydraulic press is mounted in the vacuum press section. The hydraulic pump and control system is mounted below the press section. Various dies and die heaters can be used in the press. Electric-power-supply connections are provided in the boxes for the die heaters as well as for other apparatus that may be used.

DESCRIPTION

The over-all length of the vacuum dry-box system (Fig. 1) is 75 in. The maximum width is 23 in., and when it is placed on the special stand, the height is 75½ in. The glove ports are at a convenient height of 44½ in. above the floor.

The right-hand side of the vacuum dry-box system contains the 50-ton press. Additional vacuum dry boxes can be added by removing

the end plate and extending the line. The vacuum dry box to the left of the press box is called the sample preparation section. The cylindrical assembly at the left end of the preparation section serves as an air lock for the transfer of material into the system.

During the pumping operation, when air is exhausted from the system, metal cover plates are fastened over the glove ports. Tubing is permanently fastened to each glove port, which exhausts the air from between the cover plates and the external side of the gloves. This provision is made to equalize the pressure on both sides of the gloves to prevent them from being sucked into the boxes.

When heaters are in operation, the pressure in the vacuum boxes will increase. A differential pressure switch is used to operate a solenoid valve in the exhaust system to maintain a constant box pressure.

The hydraulic press (Fig. 2) is supplied from an external 1¼-gpm pump driven by a 2-hp motor. The maximum pump pressure is 2000 psi. The hydraulic-reservoir and motor-pump combination is a separate assembly located under the vacuum dry-box assembly.

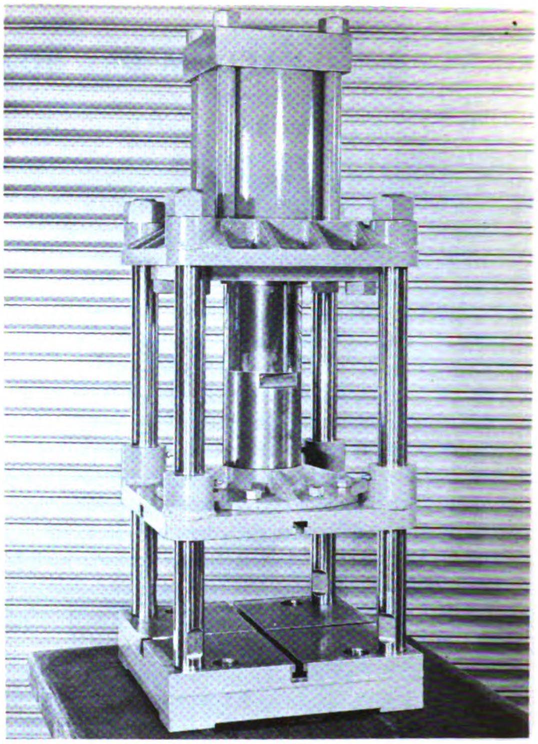


Fig. 2 Fifty-ton hydraulic press.

OPERATION

Before an experiment is started, the required equipment is placed in the system. The boxes are then sealed for pumping. After the inert atmosphere has been introduced, material is transferred through the air locks.

REFERENCE DATA

Location: Los Alamos Scientific Laboratory.

Reference Drawings: Double Dry Box, Vacuum 26Y-70240-E-1; 50-ton Press 26Y-70241-E-1; Hydraulic Schematic—50-ton Press 26Y-70241-C-9; Stand for Double Dry Box 26Y-70255-E-1.

GENERAL-PURPOSE HOOD

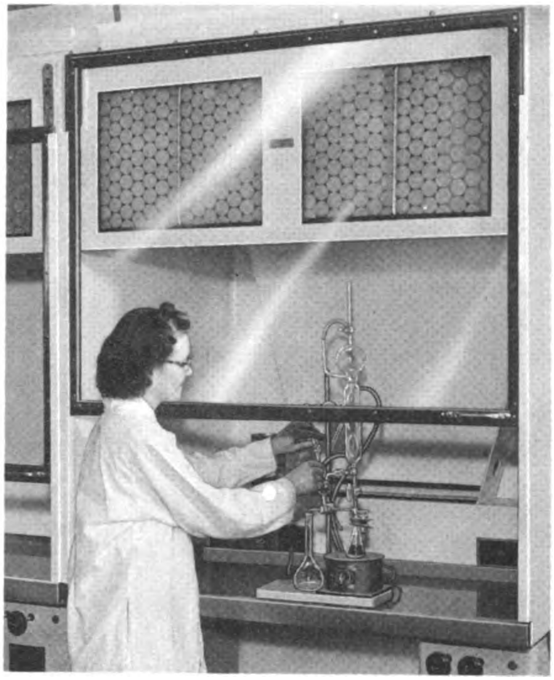
APPLICATION

This hood is well suited to alpha-activity work, including high-level experiments where the sliding window is replaced by a glove-port panel, and to low-level beta-gamma work where shielding up to 3 tons can be used.

DESCRIPTION

Hood ventilation is downdraft to eliminate condensate damage and is constant volume to simplify the controls. The hood is 48 in. wide, 36 in. deep, and 59½ in. high. It is designed to rest on a 36-in.-high base, and its back is stepped up to fit over an enclosed pipe chase 3 ft 8 in. high with a reagent shelf 7⅝ in. deep. It is built of aluminum employing frameless wrap-around construction to minimize the number of contaminable crevices. The interior is painted with strippable paint. The bottom is an 18-gauge stainless-steel tray. The 6-in. projection of the rear contains a V-shaped plenum chamber which leads at its lower end into the exhaust duct. The plenum has a removable baffle at the front and shelf spaces at either side. The rear of the hood beneath these shelves has two access openings for the service piping and electrical receptacles to project from the room wall into the hood. The stainless-steel framed shatterproof-glass window is suspended by sash balances. It passes, in opening upward, across a pair of filtered bypass windows, achieving constant volume control. Full-width external fluorescent light illuminates the hood interior through a glass window in the top of the hood. The base is 48 in. wide, 30 in. deep, and 36 in. high. It is capable of supporting loads of 6000 lb. The stainless-steel-base top has an opening allowing the hood to accommodate floor-mounted equipment when the hood tray is removed. Remote valve operators are provided in the base to engage the utility valves in the laboratory wall.

The base is modified to provide single or four-compartment sinks with foot-operated service valves. The hood is modified to hold a two-tiered drying rack in conjunction with the sinks.



OPERATION

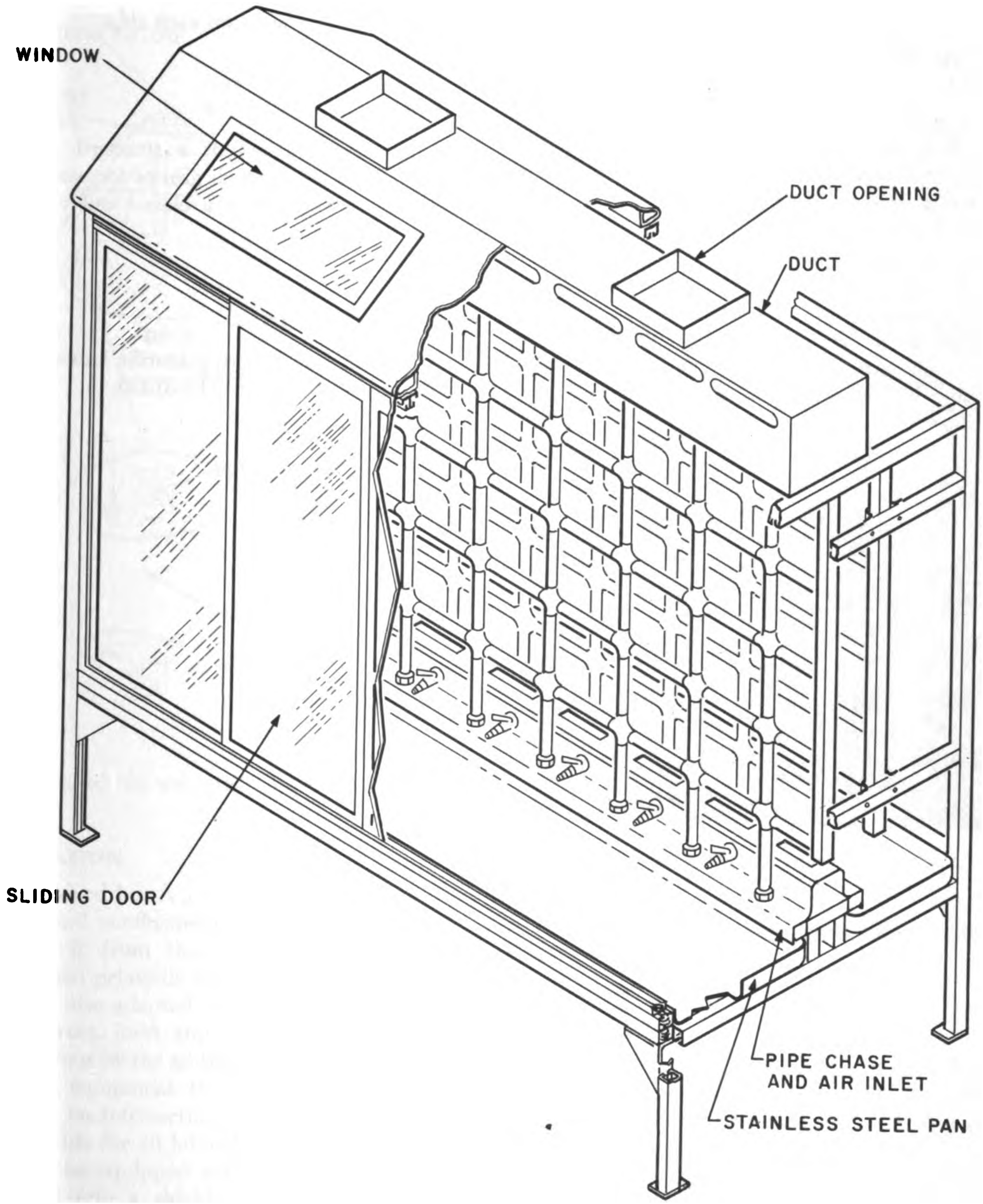
The hood is designed for operation with a minimum face velocity of 150 fpm with the window in any position below 18 in. open. The window can be raised completely out of its tracks for maintenance, or it can be opened 36 in. for equipment installation in the hood. The rear shelf is convenient for holding equipment such as drying jars which do not require frequent attention.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Drawings: Drawings H-3-4848, Sheets 1 to 10.

VACUUM BENCH



Cutaway view of exterior of vacuum bench.

APPLICATION

The vacuum bench was designed for hot-laboratory use to provide greater work space than is available in an ordinary chemistry fume hood.

DESCRIPTION

The vacuum-bench enclosure is approximately 8 ft long, 4 ft wide, and 5½ ft high. It is made of stainless steel and is equipped with four safety-glass sliding doors on each side. A double rack is located in the center of the enclosure, which is used for assembling glass apparatus for various experiments.

Utility outlets for gas, water, vacuum, and air are spaced along the bottom of the racks. The enclosure is designed for positive ventilation, with air introduction along the entire length of the utility housing. The air is exhausted into a plenum running the full length of the enclosure in the top section.

Depending on the capacity of the exhaust system, the vacuum bench is designed to handle a maximum air-face velocity of 100 fpm with one sliding door open on each side.

OPERATION

The vacuum bench is a standard assembly used by various research groups for work which must be carried out in a closed and ventilated hood.

REFERENCE DATA

Location: Los Alamos Scientific Laboratory.
Reference Drawing: 11Y-31330.

GLOVED BOX OR MANIPULATOR BOX

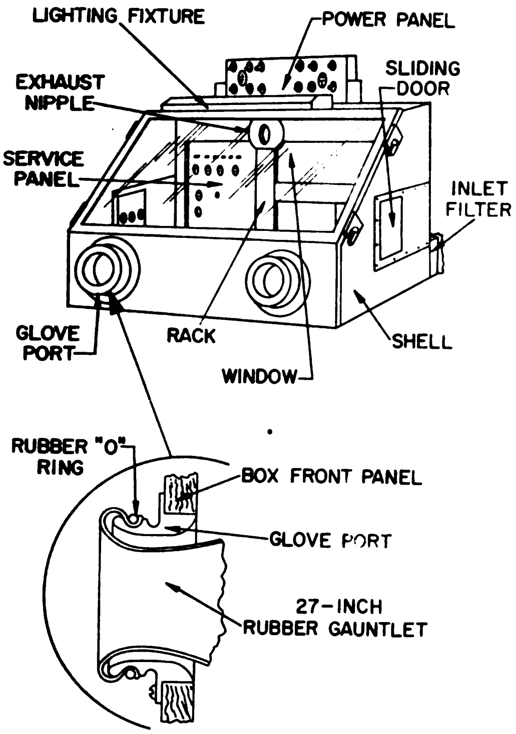


Fig. 1 Gloved box with detail of gauntlet installation.

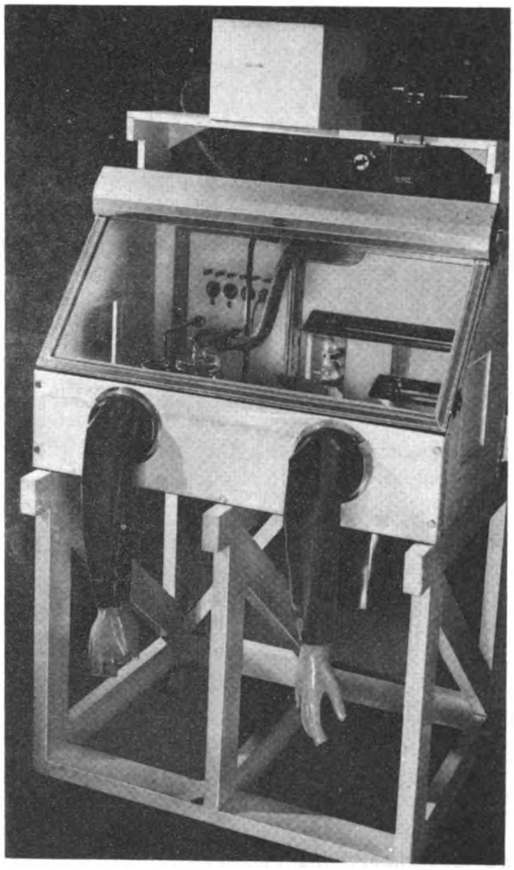


Fig. 2 Fully equipped gloved box on dolly.

APPLICATION

The gloved box is a mobile total enclosure for control and confinement of hazardous material, isolating it from the operator's environment. While used primarily for work with alpha emitters, it is also adapted for work with low-energy beta sources, inert atmospheres, and biological preparations by the addition of shielding. When enclosed equipment is remotely operated and arranged on intersecting circles, the gloved box is adaptable for all laboratory procedures. The box may be equipped with demountable shields or rolled into a shielded stall to keep backgrounds low. In some instances the box is used for extremely low-level work, in which case the box atmosphere can be kept substantially cleaner than that in the laboratory.

DESCRIPTION

The gloved box (Fig. 1) consists of a shell of painted ¾-in. plywood assembled from interchangeable panels. The bottom panel may be plain or have a hole for a well centrifuge installation. The back panel supports the following: a disposable equipment-mounting rack, a service panel, the exhaust nipple, a power panel, and an inlet filter system. Side panels have slid-

ing doors for introduction or removal of samples or equipment. The top panel has a window on which rests a fluorescent-light fixture. The front panel mounts two glove ports, and a framed safety-glass window (18 by 36 in.) provides a view of the interior.

OPERATION

The box is usually supported by a dolly, as shown in Fig. 2, and 27-in. rubber gauntlets are attached to the ports. A blower, or some other exhaust system, draws air out of the box through a high-efficiency filter. Fresh air enters the inlet filter at an average rate of 10 cfm. Under these conditions, a slight negative pressure of about $\frac{1}{16}$ in. of water exists within the box. This serves to prevent air-borne radioactive particulates from migrating out through the doors when opened or through any other apertures. A plastic-coated tray fills the bottom of the box, and polyethylene film is taped to the inside face of each wooden panel. These aid in decontamination and salvage of the box at the end of the operation and add corrosion resistance. The tray catches spills and simplifies recovery of valuable materials.

A variety of specially designed accessories provides all the working features of a standard laboratory bench and hood (see pages 87, 89, 199, 201, 209, 213, 215). Microchemical techniques and equipment are most frequently utilized, and 40- and 15-ml centrifuge cones are the largest vessels used for most operations. Operations are planned in advance so that equipment and necessary reagents are in place in the box before the work commences. Active materials are brought in and samples removed in secondary containers passed through the doors. Waste volumes are normally small and are allowed to accumulate inside the box. Equipment remains in the box until decontamination—after the chemistry is completed.

REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

Shell 4J9874C, 4J9884K, 4J9894F, 5J4954B, 5J4964B, 5J4974C, 5J4984D, 5J4994F, 7J4653A, 4J4572I.

Front Panel 2M5933A, 3F5203A, 4J4344B, 5J8914C, 4D3652A.

Top Panel 2M5944G, 4J7713D, 5J5004B.

Window Panel 2M5962, 4D5672, 2M6021C, 5J5161.

Feed Panel 6J4413A.

Tray 3F5122C, 3F9323B, 5J5283, 6J9051, 3F9292B, 3F9301B, 3F9311B.

Glove Port 5J1292A.

Lighting 4D4383, 5J6011A.

Power Control Sub-panel 2T7962F, 2T5344H, 2T5353A, 2T5362A, 2T8251A.

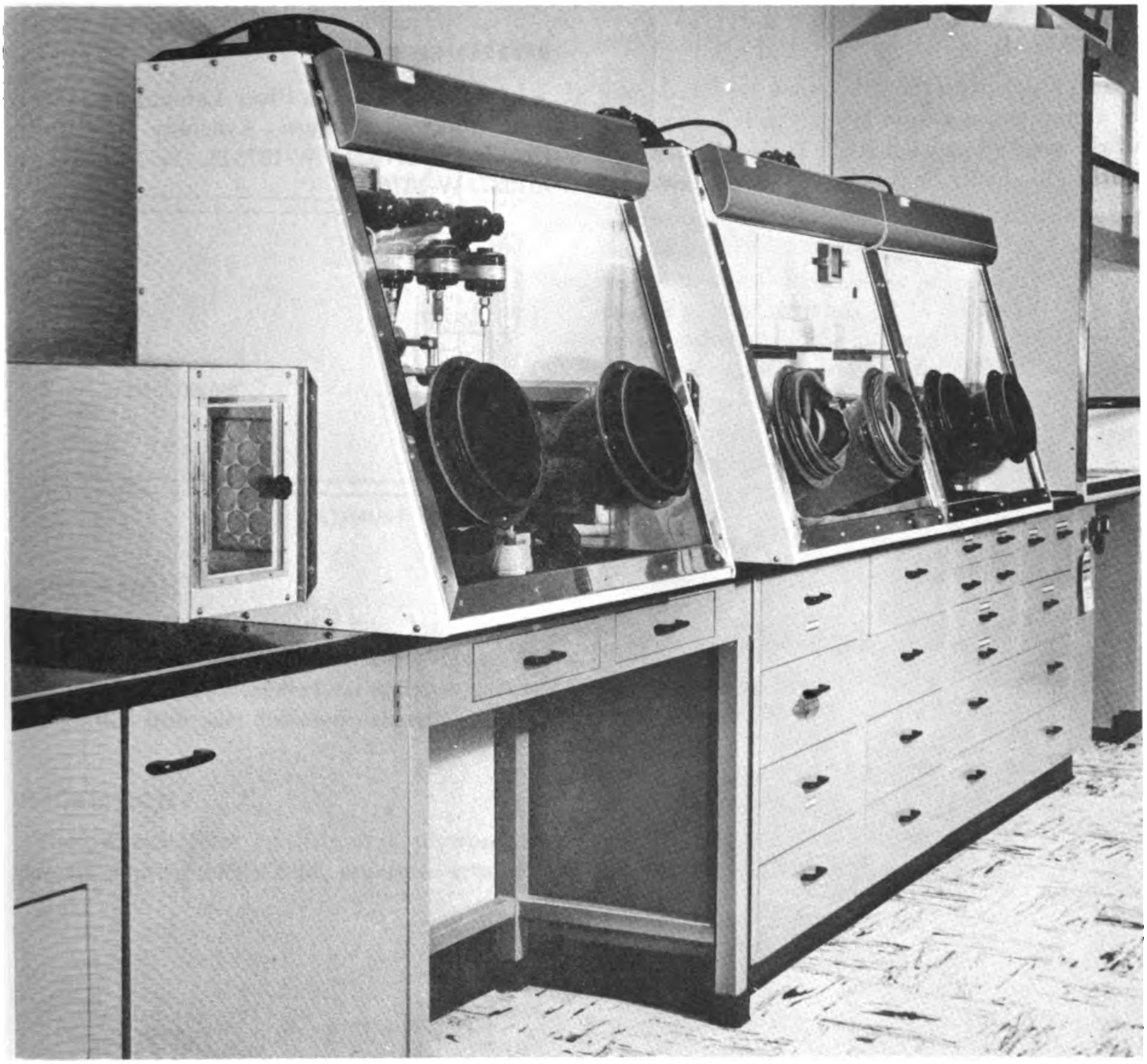
Dolly 6J3964.

Interchange 4J7074B, 5J2721A, 4J7081B, 5J2731A.

Reference Documents: Nelson B. Garden, Semihot Laboratories, *Ind. Eng. Chem.*, **41**, 237 (1949).

J. G. Conway and M. F. Moore, Spectrographic Analysis of Radioactive Materials, UCRL-1138, Feb. 23, 1951.

GLOVED BOX



APPLICATION

The gloved box is designed to protect personnel and prevent spread of contamination when laboratory experiments are performed with alpha-emitting isotopes at the millicurie level. It may also be used with low levels of beta-gamma activity and with other toxic materials.

DESCRIPTION

The gloved box is 32 in. high, 37 in. wide, and 23 in. deep. It is fabricated from ⅝-in. plywood with laminated plastic-impregnated surfaces and is available either with or without a centrifuge well. Accessories provided are a fluorescent light, a shelf, a ring stand, air locks, and an electric service panel.

The 8-in.-diameter gloved ports are mounted in a solid plate-glass front. Fiber-glass inlet filters are mounted in sliding doors at the side of the box. The exhaust filter is readily removed from inside the box. The box is designed to exhaust about 10 cfm.

OPERATION

The boxes, with the side panels removed, may be connected in a train to give an uninterrupted work space of any length. They may also be used individually or connected with an air lock. The front panel may be removed for installation of equipment.

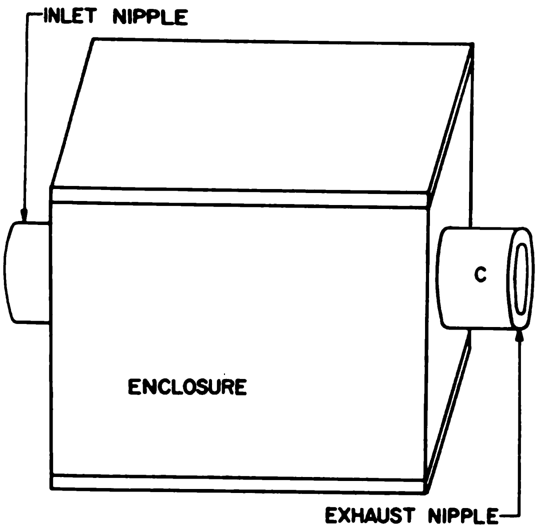
The gloves are 8 in. in diameter at the gauntlet and 30 in. long. All parts of the box are easily accessible when working with these gloves through the gloved ports.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawings: Assembly W-157623; Details W-157624, W-157625, W-157626, W-157627, W-157628.

EXHAUST FILTER



APPLICATION

This unit is used with the 2-in. lead-shielded manipulator box and the gloved box (page 83) to control the discharge of radioactive particulate matter from the enclosed exhaust.

DESCRIPTION

The exhaust filter consists of a plywood enclosure, approximately 9 in. square in cross section, housing a standard pleated paper filter of 20 cfm capacity and a forefilter of graded glass fibers. Inlet and exhaust nipples connect the filter to the enclosure and vent, respectively.

OPERATION

A 2-in. nipple at the back of the box is connected by a flexible tube to the inlet nipple of the filter. The discharge nipple is similarly connected to an exhaust vent. Under normal operating conditions the flow through the filter does not exceed 20 cfm at a maximum pressure drop of 3 in. of water. To prevent degradation of the filter media a condenser or acid-mist scrubber is used before the inlet to the filter.

REFERENCE DATA

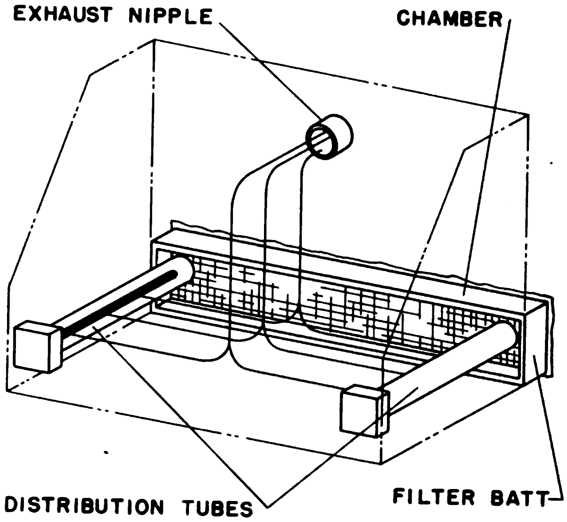
Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL	4J7064C	5J7552	6J1233
	HC05611	5J7561A	6J1242
	6J5501	5J7571A	6J1252
	5J8872	5J7581	6J1261
	6J5513	5J7591	6J1271

Reference Document: UCRL-672, Air Filters; Simplification of Fine Glass Fibre Mounting.

INLET FILTER



Inlet filter system.

APPLICATION

This unit is used to provide clean air to the interior of 2-in. lead-shielded manipulator boxes and gloved boxes (page 83).

DESCRIPTION

The inlet filter consists of a chamber extending across the back face of a box. A screen supports a bat of glass-fiber filter media. At 10 cfm the pressure drop is less than 1/8 in. of water.

OPERATION

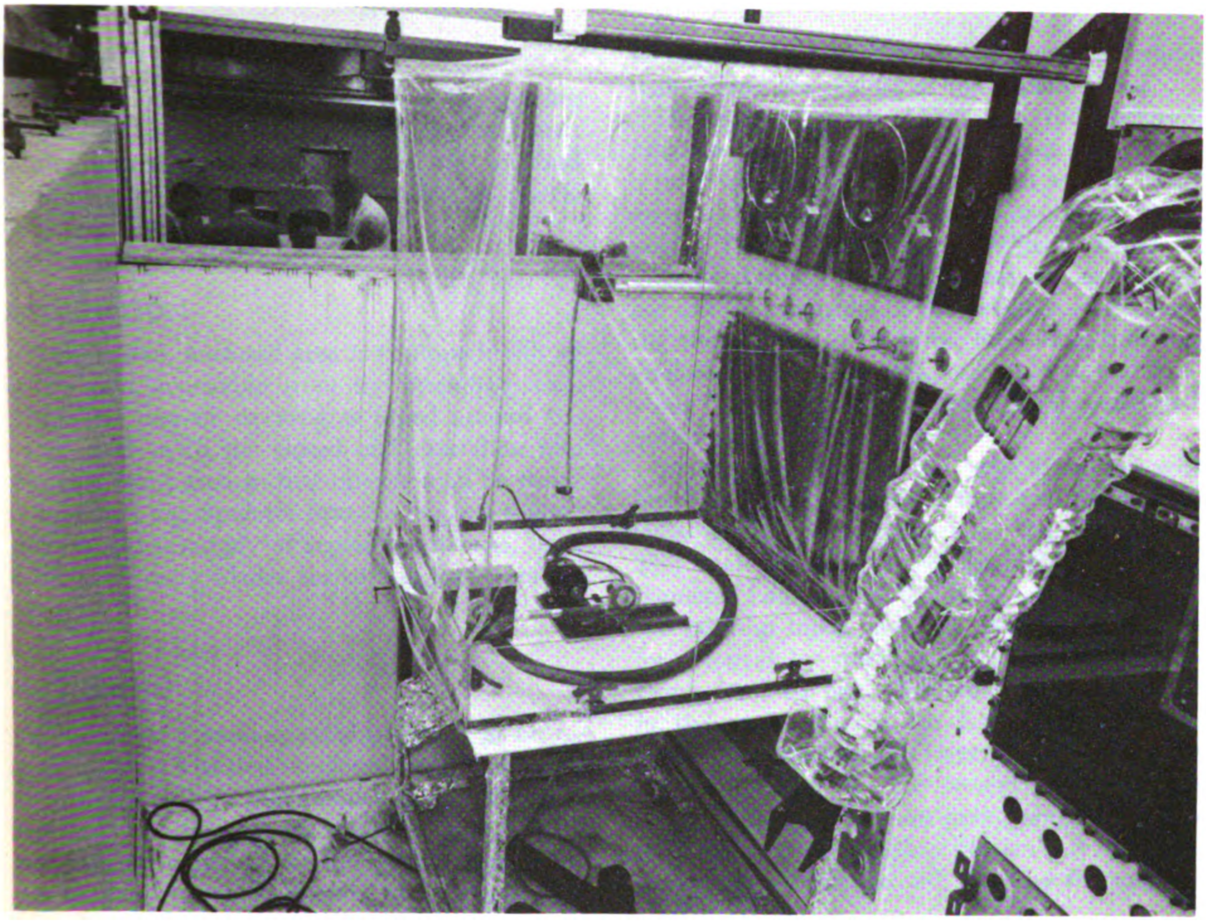
Air is conducted through the filter media, dispersed at either side of the box through the distribution tubes, and collected at the top of the box by the exhaust nipple.

REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings: UCRL 4J7682B
7J8353A
4J7692A

EXPENDABLE PLASTIC CUBICLE



APPLICATION

The plastic cubicle serves as a contamination barrier between the enclosed experiment and the general cell area.

DESCRIPTION

The cubicle is a rectangular box made of vinyl chloride acetate film 0.004 in. thick. Loops are heat-sealed to the top for attaching to remotely operable quick-release brackets in the cell. In the side adjacent to the window wall there are two holes for the insertion of plug-in master slaves. On the side opposite the window, there is a flap giving access to the inside of the cubicle.

After an experiment, the equipment on the table top inside the cubicle is either remotely decontaminated and removed from the cell or scrapped. The cubicle is detached from its supports and disposed of remotely. Gross contamination stays inside the cubicle.

During operation an exhaust system keeps the inside of the cubicle at a slightly lower pressure than the general cell area.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: RML-SK-302A.

AIR-LOCK PASS BOX

APPLICATION

The air-lock pass box is a means of transferring objects in and out of a sealed, enclosed area while maintaining the seal. By this method contaminated objects may be sealed in plastic bags and removed safely.

DESCRIPTION

The sealed, enclosed area is equipped with an entry port accessible from the operating area. A plastic bag or stocking is taped around the entry port, with the closed end extending into the operating area so that objects may be transferred by a manipulator into the bag. A sealing device and a supply of replacement bags, tape, corks, and razor blades are kept in the operating area.

OPERATION

Whenever a contaminated object is to be removed from a sealed, enclosed area, the object is transported by a manipulator to the entry port leading from the operating area, at which point the object is placed in the plastic bag. The plastic bag is seamed closed (by means of heat or other sealing method) over a ½-in.-wide strip along its width. This seam is made at a point between the open contaminated end and the closed operating end enclosing the contaminated object. A cut along the middle of the ½-in. seam permits removal of the bagged object while maintaining the sealing of the enclosed area.

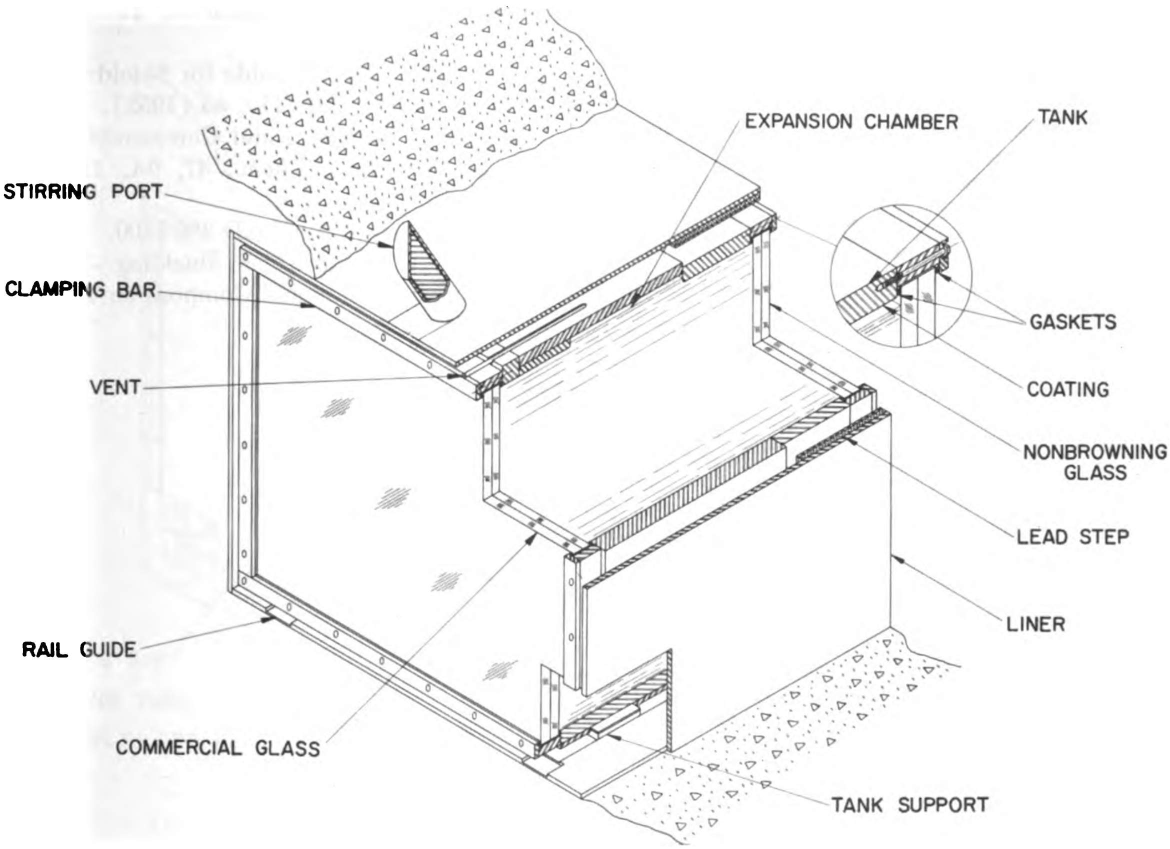
Objects to be introduced into the enclosed area are placed in a new plastic bag, along with a razor blade which is mounted in a cork. The open end of the bag is taped around the entry port. The cork holding the razor blade is grasped through the plastic bag and is used to cut out the remnants of the previous bag, clearing the entry port to admit the object into the enclosed area. The cork, razor blade, and previous bag remnants are stored in the enclosed area for later disposal.

Many operations of the type described will build up a large supply of tape and plastic-bag ends around the periphery of the entry port. This material is removed by taping a larger-diameter bag around the entry port, such that the built-up tapes and bag ends are accessible for removal by working them off through the larger-diameter bag, after which they are stored in the enclosed area for later disposal. The larger-diameter bag can then be retaped around its periphery so that the second taping will be located around the entry-port periphery in the same place as the built-up portion just removed. Succeeding operations will then use the smaller-diameter bag.

REFERENCE DATA

Location: Mound Laboratory.

LIQUID-FILLED SHIELDING WINDOW



Cutaway section of installed liquid-filled window.

APPLICATION

General viewing windows are useful when the restrictions of periscopes cannot be tolerated. They provide a wide angle of view and allow minimum distance between the operator and his work.

Zinc bromide solution–filled windows match ordinary concrete in shielding power but may also be used in high-density concrete walls. In the latter case, the window must be thicker than the wall for full shielding. The maximum window thickness is 4½ ft because of radiation-induced gas generation in the liquid at intensities of more than 5×10^4 r/hr. The most important advantages of a zinc bromide window are the high optical quality and moderate cost. After installation they require no further attention for many years.

DESCRIPTION

A liquid-filled window is essentially a rectangular tank provided with two glass cover plates and filled with optical-grade zinc bromide solution. The over-all dimensions of a typical window are 30 by 36 by 36 in. thick. This window will have a transmission value for sodium-vapor light of about 30 to 50 per cent. It is either cast directly into the wall or inserted into a liner which is cast in the wall. Use of a liner allows assembly in a clean area and insertion at the builder's convenience. The clearance between

the window and liner is shielded with lead steps attached to the liner.

The hot-rolled steel tank is of welded construction. Machining is required only on the gasket surfaces. Gaskets are ⅛ in. thick laminated to ¼ in. thickness. The tank interior is painted to prevent corrosion. The glass cover plates should be 2 in. thick except in the smaller window sizes. These may be solid or laminated from two 1-in.-thick plates. Nonbrowning glass is required on the high-radiation-level side.

A stepped internal expansion space is provided to allow for thermal expansion of the liquid. A filling and stirring port is provided to permit thorough mixing of the liquid at the time of installation.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Documents: "A Manual of Remote Viewing," ANL-4903.

K. R. Ferguson, Design and Construction of Shielding Windows, *Nucleonics,* **10** (11), 46 (1952).

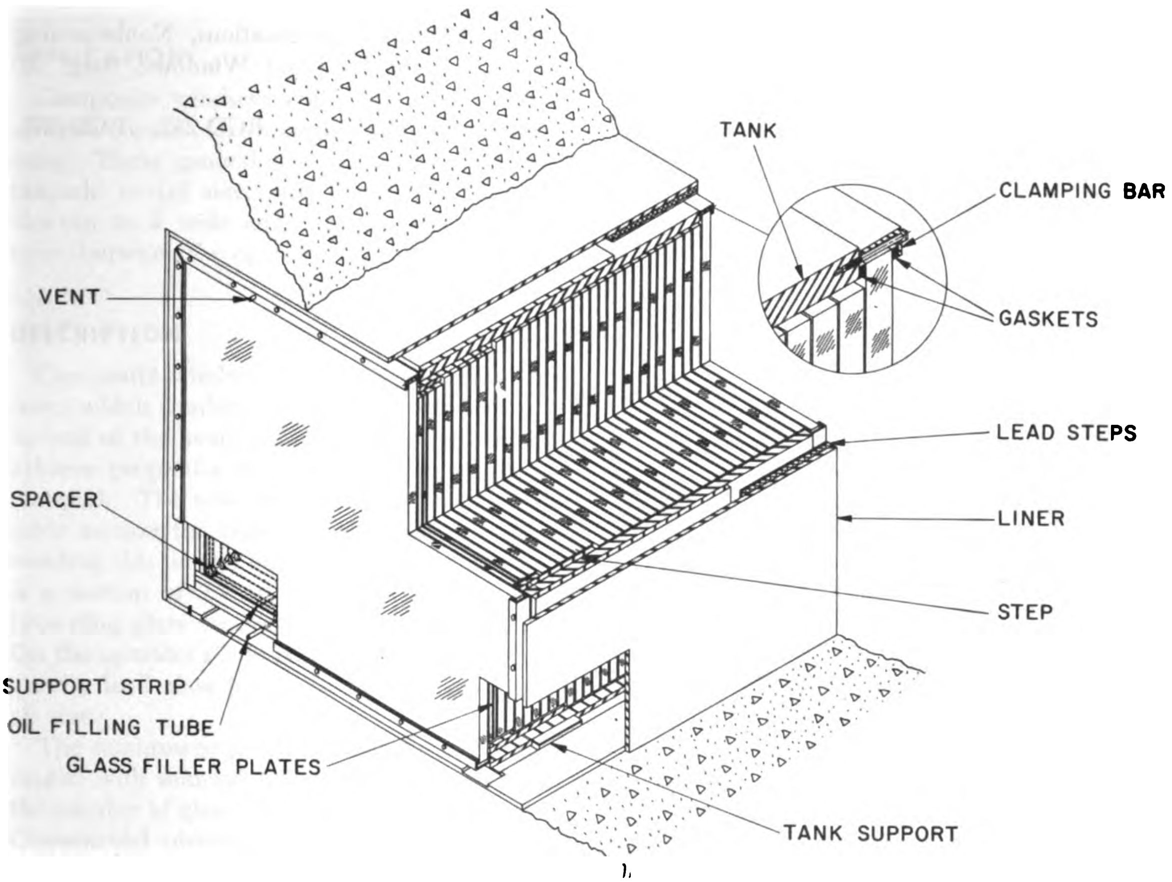
W. B. Doe, Zinc Bromide for Shielding Windows, *Nucleonics,* **10** (11), 46 (1952).

Report on Technical and Commercial Development, *Ind. Eng. Chem.,* **47,** 9A, 11A, 13A (1955).

Reference Drawing: RCD-380-1100.

Patent: U.S. 2,683,650 Shielding Window against Radioactivity and Composition Therefor.

GLASS-FILLED SHIELDING WINDOW



Cutaway section of installed glass-filled window.

APPLICATION

General viewing windows provide an unrestricted view of hot-cell operations. They provide a wide angle of view and allow minimum distance between the operator and his work.

Glass-filled windows may be used in applications which require the equivalent of 5 to 6 ft of ordinary concrete shielding. At higher radiation levels, gamma-ray-induced coloring and heating of the glass become serious. The windows can be designed to match ordinary or heavy concrete, depending on the type of glass used. The yellowish color of the glass in thick sections may interfere with color discrimination

DESCRIPTION

This type of window is a rectangular tank filled with glass plates immersed in mineral oil. Since the oil is of low density, the clearance between the edges of the glass plates and tank wall is shielded with steel steps. The glass plates are supported on sealing strips and slightly separated at the corners by copper spacers to allow penetration of the oil. The first 18 in. of glass including the cover plate on the observer's side is ordinary plate glass. The remainder of the glass is the nonbrowning type of either 2.7 or 3.3 specific gravity. Cover plates are 2 in. thick, either solid or laminated from two 1-in. plates.

The tank is sealed with gaskets, and the interior surfaces of the steel tank are coated with special varnish to prevent rusting. The tank can be cast directly into a shielding wall or inserted into a liner which is cast in the wall.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Documents: "A Manual of Remote Viewing," ANL-4903.

K. R. Ferguson, Design and Construction of Shielding Windows, *Nucleonics*, **10** (11), 46 (1952).

ANL Tentative Specifications, Nonbrowning Lime Glass for Shielding Windows, Aug. 15, 1950.

Reference Drawings: RCD-252, RCD-253, RCD-168.

COMPOSITE WINDOW

APPLICATION

Composite windows are used in high-density concrete walls for high-radiation-level operations. These general viewing windows are particularly useful since they provide unrestricted viewing at a wide angle with a minimum distance between the operator and his work.

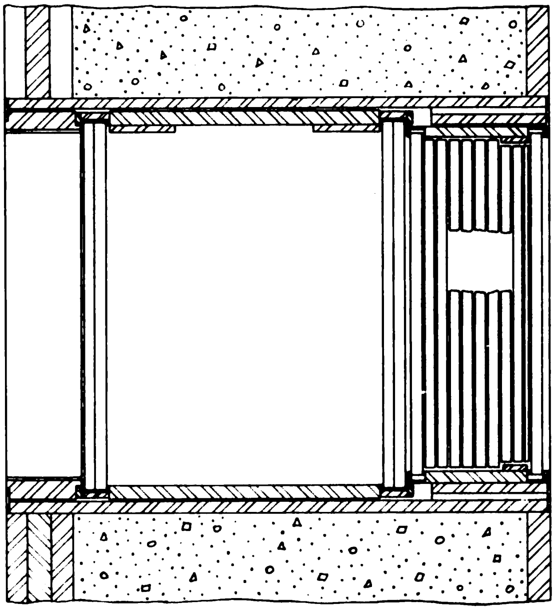
DESCRIPTION

Composite windows are multiple-section windows which combine the desirable properties of several of the available transparent materials to achieve properties not possible with any single material. The window is basically a zinc bromide section for high optical quality. Supplementing this on the high-radiation-intensity side is a section of 2.7 or 3.3 specific gravity nonbrowning glass for radiation-damage resistance. On the operator's side is a section of 6.2 specific gravity lead glass to reduce the window's overall size.

The nonbrowning section may be either laminated with mineral oil or air-laminated where the number of glass-air interfaces is not excessive. Commercial plate-glass cover plates should be used to protect the lead-glass section.

REFERENCE DATA

Location: Argonne National Laboratory.



Cross section of composite window.

Reference Documents: "A Manual of Remote Viewing," ANL-4903.

K. R. Ferguson, Design and Construction of Shielding Windows, *Nucleonics,* **10** (11), 46 (1952).

M. H. Bartz and J. B. Burnham, Hot Cell for Testing MTR Irradiated Specimens, *Nucleonics,* **12** (11), 42 (1954).

LEAD-GLASS WINDOWS

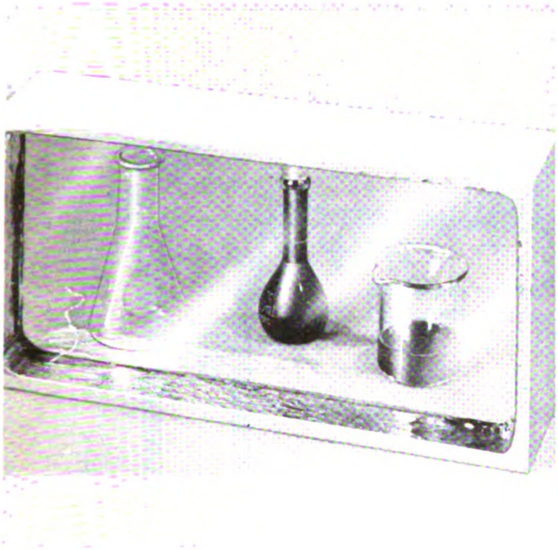


Fig. 1 View through lead-glass slab with glass leaded to steel frame.

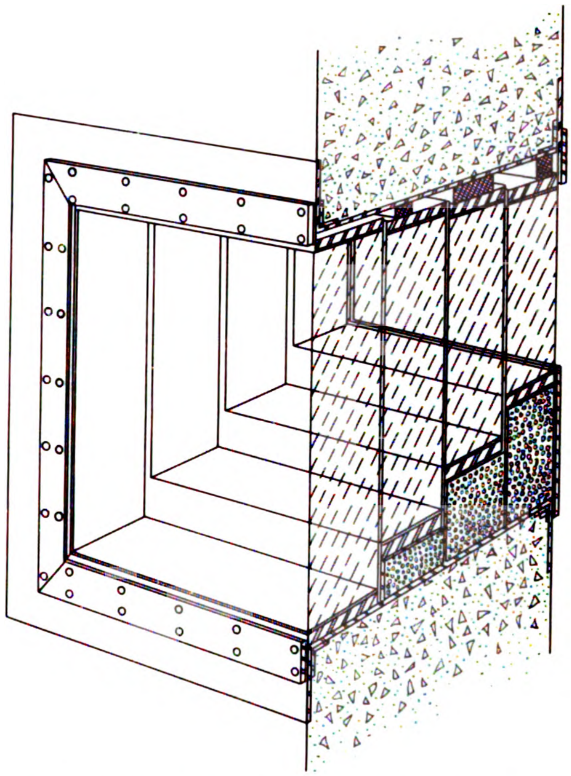


Fig. 2 Cross section of permanent wall showing lead-glass slabs in window.

APPLICATION

Lead-glass windows are used for viewing through high-density shielding walls. They provide gamma shielding power equal to that of steel. The maximum usable thickness is about 8 to 12 in. because of gamma-induced coloration. The yellow or orange intrinsic color of the glass may interfere with color discrimination. Typical uses are as windows in permanent walls, transparent bricks in temporary walls, windows in portable shields, and shielded hoods. They are also used in conjunction with other transparent materials in composite windows.

DESCRIPTION

The window consists of bricks or slabs of high-density lead glass with or without integral metal frames. When several slabs are used, the internal air spaces are dried with a desiccant. The exterior surfaces of the assembly are protected with commercial plate-glass covers.

REFERENCE DATA

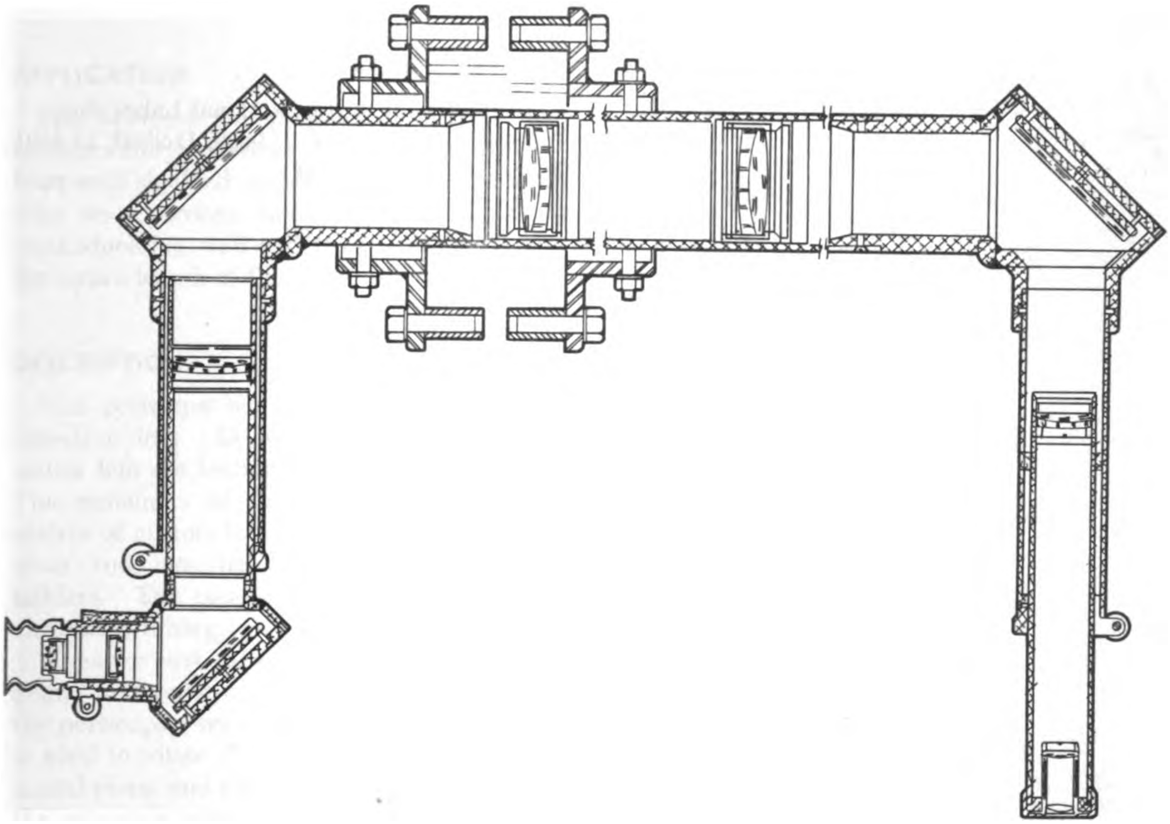
Location: Argonne National Laboratory.

Reference Documents: R. A. Blomgren and N. J. G. Bohlin, Mobile Shield for Cyclotron Target Removal, *Nucleonics*, **12** (11), 62–63 (1954).

"A Manual of Remote Viewing," ANL-4903.

Reference Drawing: RCD-410-4000.

PERISCOPE FOR HOT-CELL MICROSCOPY



Cross section of periscope.

APPLICATION

The microscope used in a hot cell requires an extended periscope of good optical quality and definition with sufficient field size for the application. This periscope is used in conjunction with the microscope of a hardness tester for examination of irradiated metallurgical specimens subjected to the hardness test.

DESCRIPTION

A vertical eyepiece adjustment, with no appreciable magnification or reduction in image or change in field, is provided to accommodate operators of various heights. The section of the periscope passing through the cell wall is about 57 in. long, and the section within the cell is about 19 in. high. The exterior section is adjustable from a height of 14 to 21 in.

Construction of the periscope housing is essentially all aluminum. Stock sizes of tubing are used for all tubular elements where applicable. The mirror boxes, or elbows, are fabricated from plate and tube or bar stock by welding. Three precision first surface mirrors are used at the periscope bends. These are mounted in universal or floating holders to facilitate alignment.

The lens elements were obtained from surplus gun sights or tank periscopes. The large extender lenses near the center of the periscope are essential in a periscope of this length to prevent a reduction in the field size.

A small adjustment is possible at the objective end to provide for optimum optical coupling of

the periscope and microscope. This adjustment is made before the cell is sealed off and requires no further attention.

OPERATION

The only operator adjustment or control of the periscope is for a comfortable working height of the eyepiece. This is accomplished by loosening a small handwheel clamp and moving the eyepiece up or down as required and tightening the clamp. The microscope and hardness tester are provided with electric drives for remote control. A manipulator within the cell is used for loading and unloading samples.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-9889, D-9890, D-9891, D-9892, D-9893, D-9894.

OPEN-TOP CELL PERISCOPE

APPLICATION

The open-top cell periscope is used to view hot-laboratory activities being conducted in a front-wall shielded open-top cell. The periscope rides on a carriage mounted on the top of the front shielding wall and is capable of traveling the entire length of the cell.

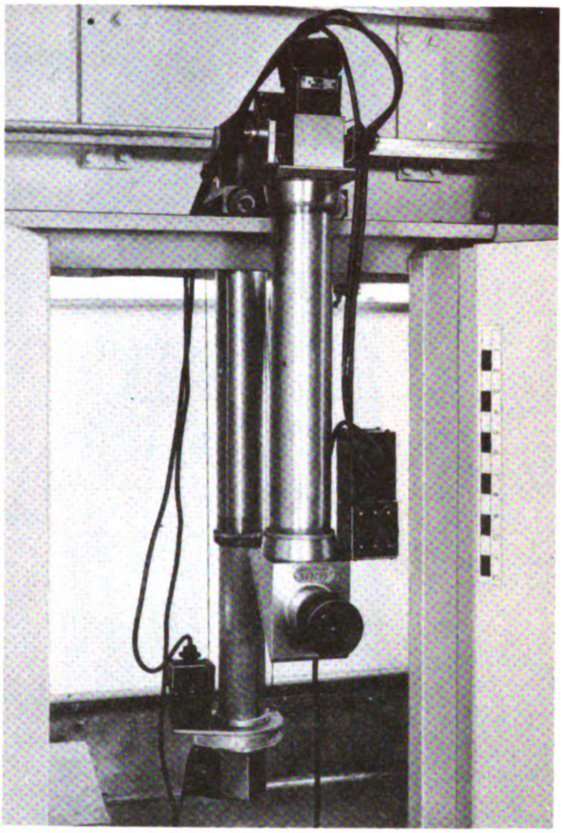
DESCRIPTION

The periscope has two erector lenses. The objective lens (15 in. focal length) and the ocular lens are both standard commercial items. The remainder of the periscope consists of a system of mirrors fabricated from optical-quality glass and mounted in cast-aluminum corner holders. The components are connected with aluminum tubing.

A power system, consisting of three motors, gears, and pulleys, has been provided to give the periscope a wide range of vision. One motor is used to rotate the scanning head in the horizontal plane, and a second motor is used to rotate the scanning mirror 45° up or down. A third motor drives a pulley, which in turn raises or lowers the entire scanning head.

OPERATION

Observations can be made at any elevation below the top face of the front shield wall and in any direction relative to the position of the periscope by proper control of the electric motors.



Open-top cell periscope—ocular side.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-5349, E-5350, D-5351, C-5352, D-5353, D-5354, C-5355, D-5356, D-3879, D-4195, D-5357.

HOT-CELL PERISCOPE

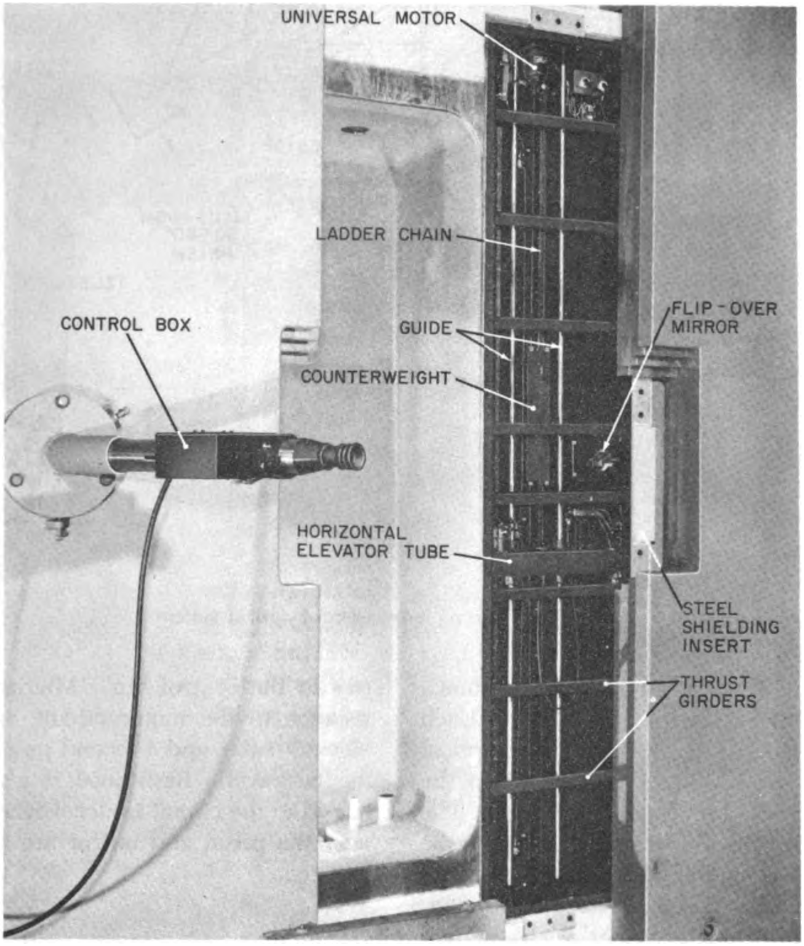


Fig. 1 View of hot cell with right door rolled back and cover plates removed to show periscope mechanism.

APPLICATION

The hot-cell periscope provides an erect unreversed view of the interior of a hot cell (see page 55) which is 4 ft wide, 3 ft deep, and 8 ft high. In its original application, two periscopes are used, providing horizontal views from the front right and front left corners of the cell. The horizontal views are adjustable in elevation. The instrument has a field of view of 25° at approximately unity magnification. The magnification may be increased by a factor of 2 for detailed observation with a corresponding reduction of field. While the field of view is reduced to about 15° at the top and bottom of the cell, this limitation is partially offset by the motor-driven scanning mechanism.

DESCRIPTION

The periscope (Fig. 1) consists of an elevator housing assembly, a telescope-tube assembly, a control box, and all necessary electrical com-

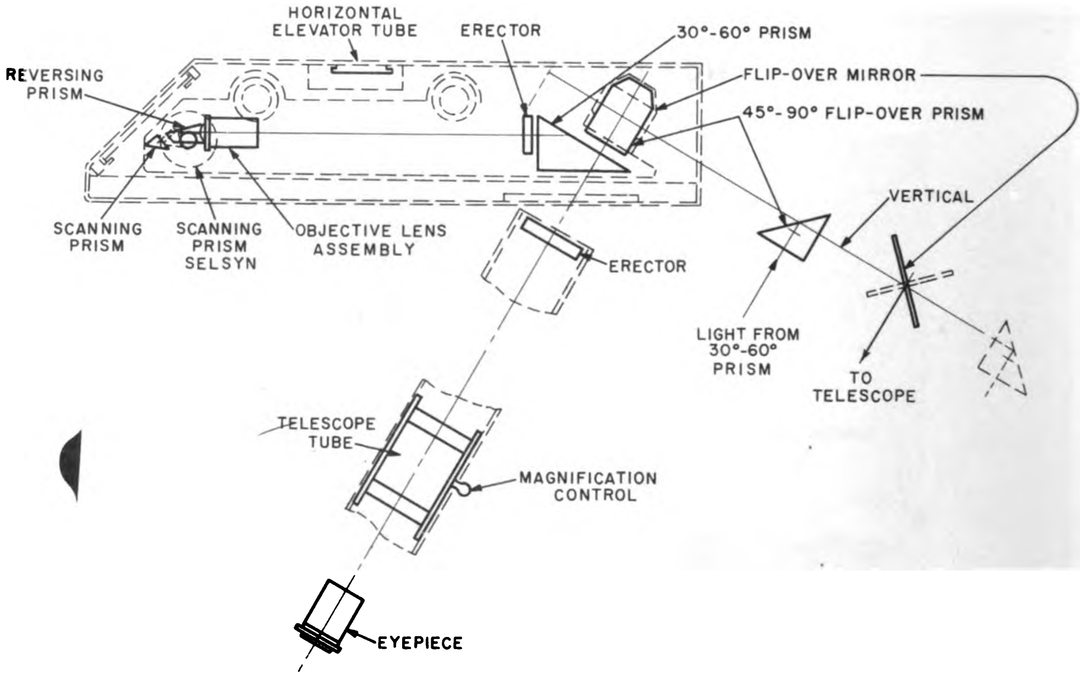


Fig. 2 Schematic representation of optical system.

ponents. A long narrow window in the housing is oriented at 45° to the cell corner. Each periscope is composed of three separate optical subassemblies, two of which are linked to the third only when the cell doors are closed. The housing unit contains a horizontal elevator tube which is carried on guide rods and is driven up and down by means of a small universal motor, ladder chain, and counterweight. The end of the tube facing the cell interior carries a scanning prism (Fig. 2), reversing prism, and objective lens, and the opposite end carries a first erector lens, stationary prism, and flip-over prism. Fixed to the rear of the housing is a flip-over mirror which links the elevator-tube optical assembly to the telescope tube located on the door. There is an inherent blind spot when the elevator tube passes the mirror, but this blind spot is covered by the telescope in the opposite front corner. The telescope tube contains the other erector lenses and prisms and an eyepiece. The variable-magnification feature is achieved by moving, as a unit, the pair of erector lenses closest to the eyepiece.

Scanning is controlled by a pair of selsyn motors in the control box. Microswitches add resistance to the motor circuit to decelerate the elevator tube, and a second pair of switches limits its travel. Resistance is also automatically added to the circuit to decelerate the tube whenever the prism and mirror are turned to a new position.

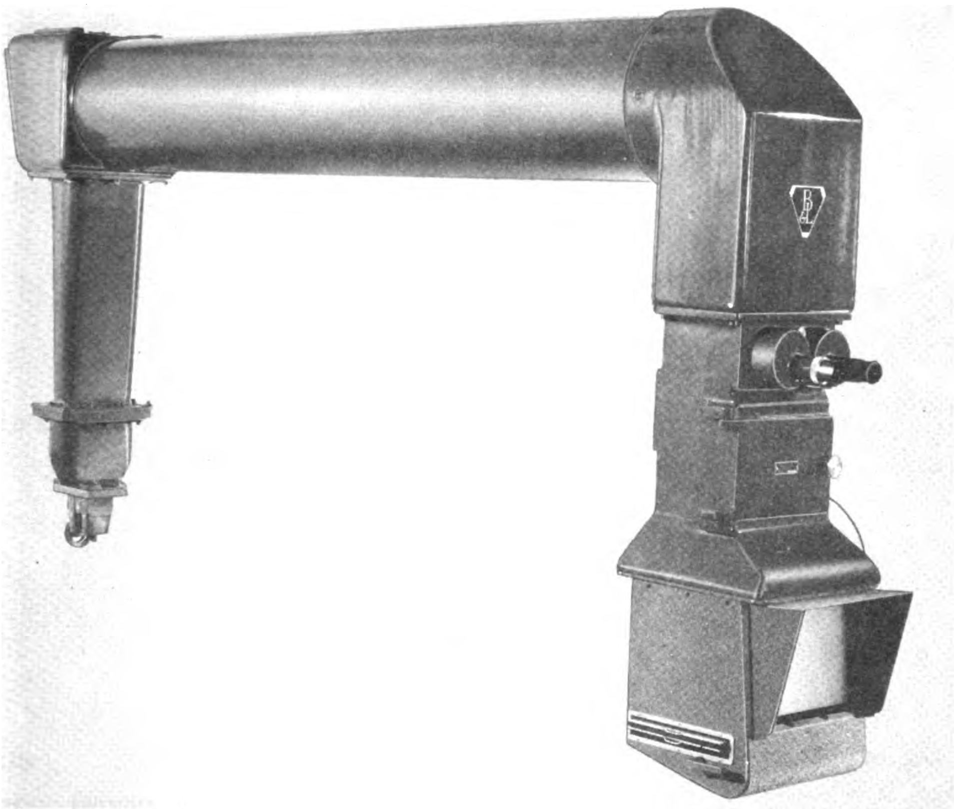
OPERATION

The periscopes are located so that two observers can use them simultaneously. Rotation of the control knob causes the prism to scan to the right or left, and an upward or downward motion of the control knob raises or lowers the elevator tube. Magnification is changed by moving the control on the telescope tube, which positions the two erector lenses nearest the eyepiece. The eyepiece needs adjustment only for objects within 12 in. of the scanning prism.

REFERENCE DATA

Location: Brookhaven National Laboratory.

STEREOMICROSCOPE AND CAMERA



APPLICATION

This commercially available stereomicroscope and camera is used through shielding walls up to 3 ft thick for stereovision and stereophotography in the magnification range from ¾ to 34 times.

DESCRIPTION

This instrument is essentially a stereomicroscope with an optical system for extending the distance between the objectives and eyepieces. A movable prism allows the optical paths to be deflected into a camera, producing stereo-pair photographs on 5- by 7-in. negatives. The magnification may be varied from 4 to 34 times by changing objectives and eyepieces. A reducing lens may be placed in front of the objective to cover the range from ¾ to 2 times. In this case, however, the field appears strongly curved.

OPERATION

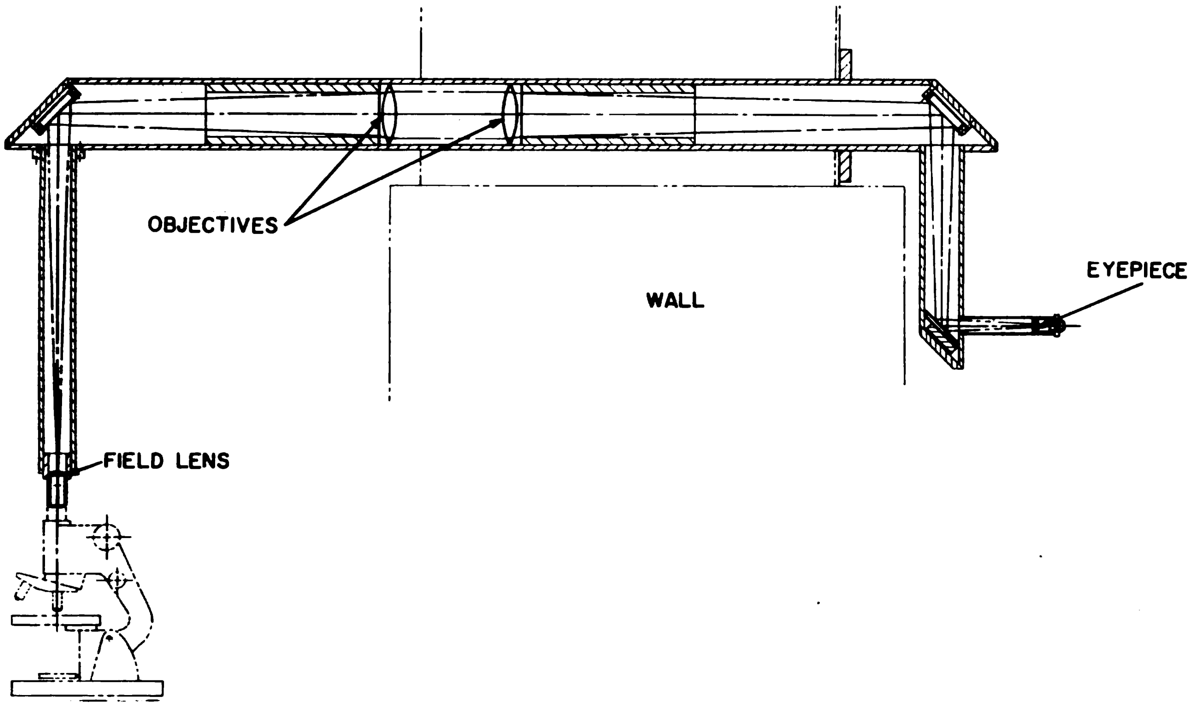
The user must provide a remotely controlled focusing stage and an objective-changing mechanism. Camera focusing may be observed on a ground-glass screen by actuating a reflex mirror.

The optical quality of the image is comparable to that of a conventional laboratory stereomicroscope.

REFERENCE DATA

Location: Argonne National Laboratory.

MONOCULAR PERISCOPE



Cross section of monocular periscope.

APPLICATION

The periscope permits the remote use in a shielded cave of optical instruments such as an ordinary bench microscope or the optics of a Tukon hardness tester.

DESCRIPTION

Optically, the periscope is a thin field lens and a pair of achromatic objectives to transfer a microscope image outside the shielding wall. The eyepiece originally supplied with the microscope is used to examine the image so formed. The inner leg of the tube is removable to permit its insertion through the shielding wall. A rubber bellows joins the periscope to the microscope to allow vertical motion for focusing. The optically flat front-surface mirrors are adjustable for the initial alignment.

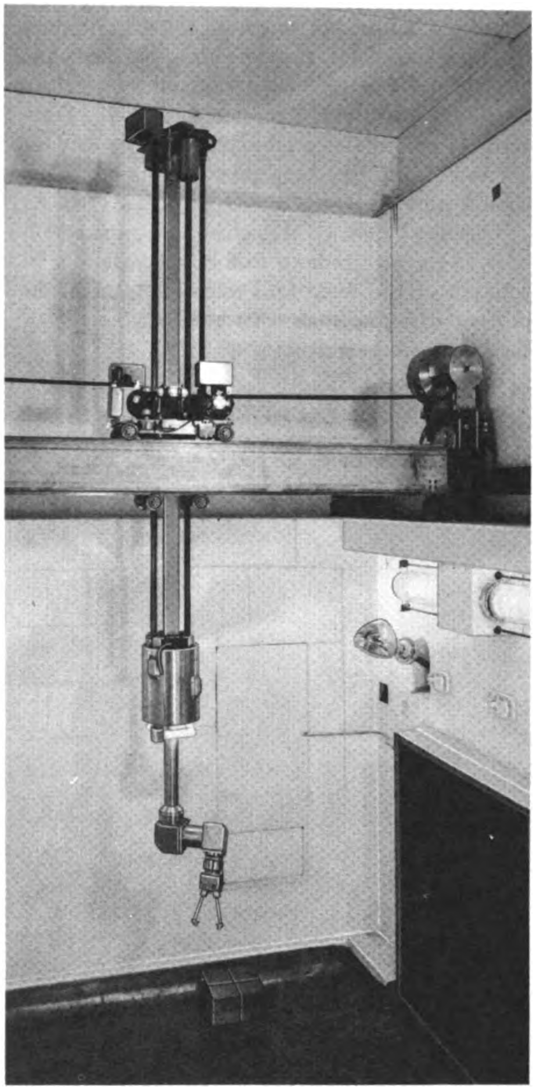
REFERENCE DATA

Location: Argonne National Laboratory.
Reference Drawing: RCD-415.

GENERAL-PURPOSE MANIPULATOR

APPLICATION

This electric rectilinear manipulator, known as the Tell manipulator, can handle weights up to 20 lb in operations above bench height in hot cells. Its all-electric operation makes it particularly applicable in banks of sealed cells where up to eight manipulators are in service. It is designed for the attachment of several interchangeable "hands."



DESCRIPTION

An eight-wheel carriage supports a vertical column and rides on a double-girder crossbeam. This crossbeam is suspended at either end from drive heads which ride on horizontal parallel rails mounted on front and rear cell walls. Motors and cable take-up reels are located on each drive head, and two motors are mounted on the carriage. A manipulative unit consisting of "shoulder," "elbow," "wrist," and detachable "hand" is located at the lower end of the column. Power supply, starting equipment, and cable reels for each manipulator are located at the end of the cell bank. Selector panels containing rotation-selector relays and sequence-timing relays are located on the front wall of each cell. On the front wall of the intercell barriers are faceplates for service and starting switches and plug-in receptacles for the relative control units. Each unit consists of a small box from which extends a pistol grip equipped with ring trigger and thumb controls. A flexible extension cord connects box to plug-in receptacle. Extra interchangeable hands are stored in racks within the cell when not in use.

OPERATION

The manipulator is driven laterally along the rails by a rack-and-pinion arrangement powered by a motor at one end of the crossbeam. At the opposite drive head a motor turns a lead screw, moving the carriage transversely. One of the motors mounted on the carriage supplies vertical motion to the column through a nut gear and lead screw. The other motor provides rotary motion through a spline gear and shaft. Continuous rotation in either direction of the shoulder, elbow, and wrist is accomplished by a single motor with a planetary-gear and magnetic-clutch arrangement. The finger-operating device per-

mits the hand to close with a predetermined pressure indicated by dials outside the cell.

To use the manipulator, the relative control unit may be hand-held or clipped in convenient operating position below the cell window. Movement of the trigger on the grip opens or closes the hand. Movement of the grip produces in the manipulator corresponding vertical, horizontal, and transverse motions, either singly or simultaneously and in either direction. Direction of motion is secured by a thumb control and a turn of the operator's wrist. Speed is also thumb-controlled.

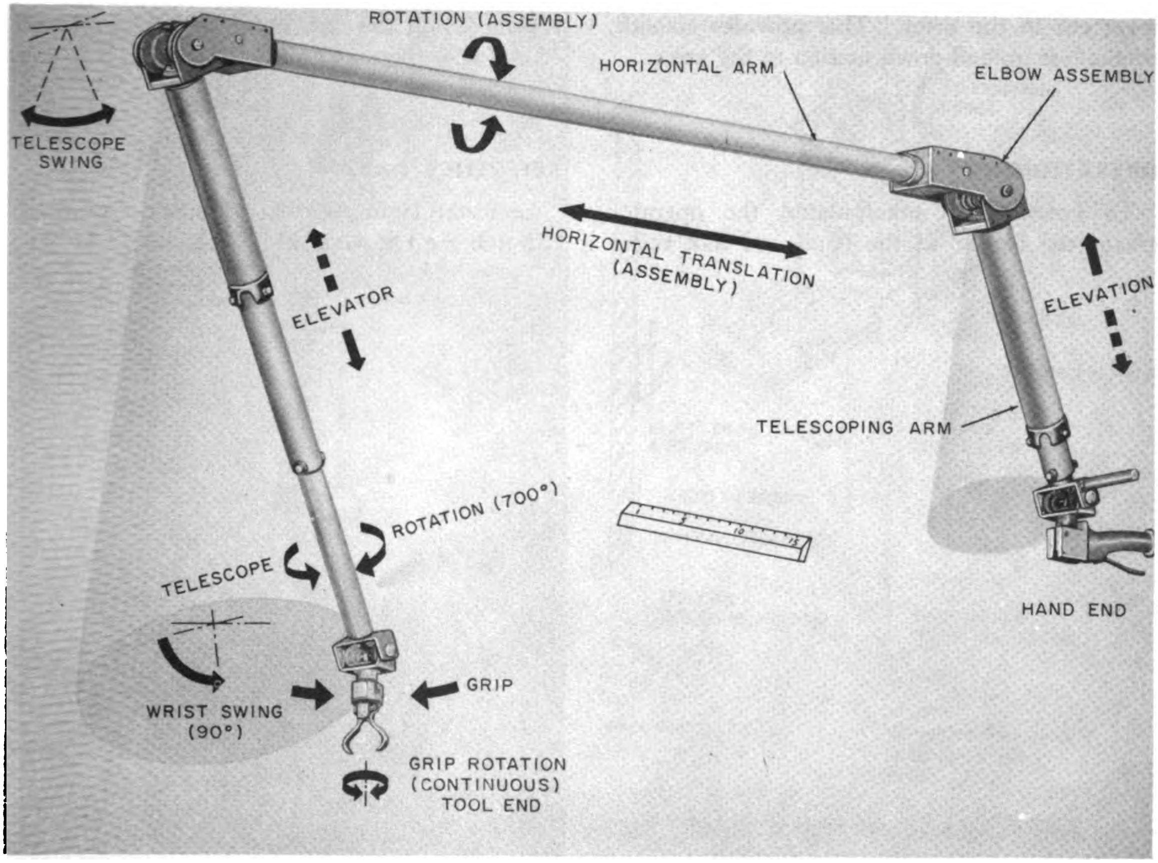
The hand may be detached and replaced by moving the manipulator to the rack, where a 90° rotation of the wrist will release the hand and deposit it in the rack. To attach a new hand, the process is reversed.

A slight amount of tipping is permitted in both crossbeam and vertical column. This flexibility allows certain manipulations without the use of all controls. The tipping feature also provides necessary travel to bring the manipulator to a stop without damage to equipment in case an immovable object is encountered. Cutouts are provided for both directions of travel and the unit returns and stops at the center if the grip is released while the manipulator is in motion. Overrun and overload damage is prevented by limit switches and clutch slips.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

SLAVE MANIPULATOR



APPLICATION

The slave manipulator is a mechanical arm used by chemists and metallurgists to operate equipment and to execute metallurgical operations safely within multicurie cells. All motions of this manipulator are directly correspondent with the exception of the vertical motions of the telescoping arms, which are reversed. While this unit was originally designed to lift only 2½ lb, it has manipulated weights of 8 to 10 lb successfully by using a counterweight attached to the "hand-end" column. It requires a minimum port diameter of 7½ in. for insertion into the cell, and it may be quickly removed for repair or transfer to some other location. Flexible shafts extending from one wrist joint to the other provide a wrist swing and a continuous grip rotation to the tool end.

DESCRIPTION

The manipulator consists of a 3-in.-diameter horizontal arm having an elbow assembly at either end to which two telescoping arm assemblies are attached. Fastened to the ends of these two arms by means of a wrist assembly are the "tool" and "hand" ends. A flexible hydraulic line connecting the trigger on the hand end to the fingers on the tool end provides a smooth, powerful grip to the fingers. To compensate for leaks in the hydraulic system or to intensify the gripping force, a hydraulic oil reser-

voir has been incorporated into a second handle protruding from the hand end. A lock on the trigger allows the operator to maintain a grip on an object for long periods of time without undue strain.

The telescoping arms are keyed to each other by means of small ball bearings rolling in keyways cut in the arms. This provides smooth, frictionless up-and-down motion to the arms.

OPERATION

To operate this manipulator, the operator grasps the handle at the hand end and raises or lowers the telescoping arms. By pressing the trigger, objects may then be gripped and positioned within the cell.

The manipulator is installed by removing one gear from the outer elbow assembly, which then permits the inner telescoping arm to be horizontally inserted into the cell. The gear is then replaced, and the arm is lowered into the cell. Removal of the manipulator is done in a reverse manner.

REFERENCE DATA

Location: Hanford Atomic Products Operation.
Reference Drawing: H-2-5711.

ELECTRIC RECTILINEAR MANIPULATOR

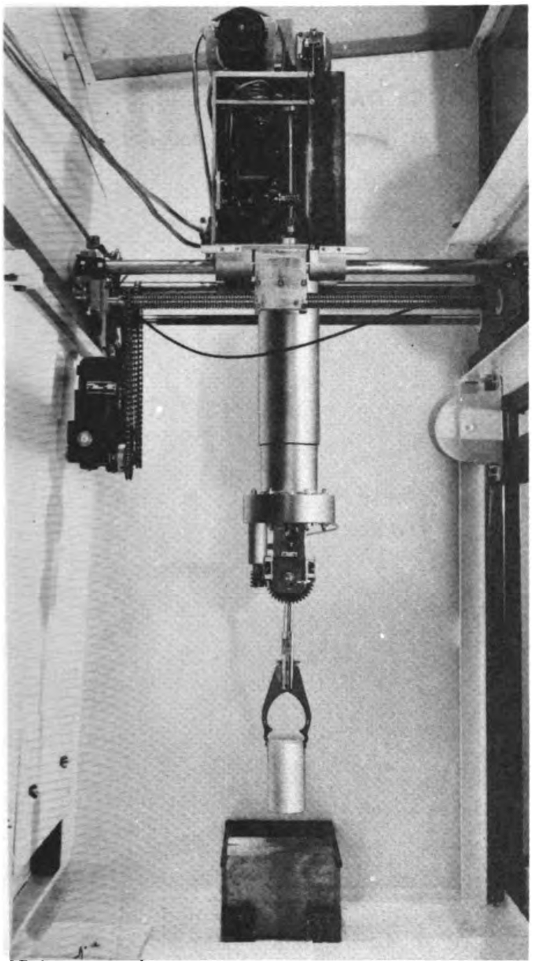


Fig. 1 Electric rectilinear manipulator operating in a semihot cell.

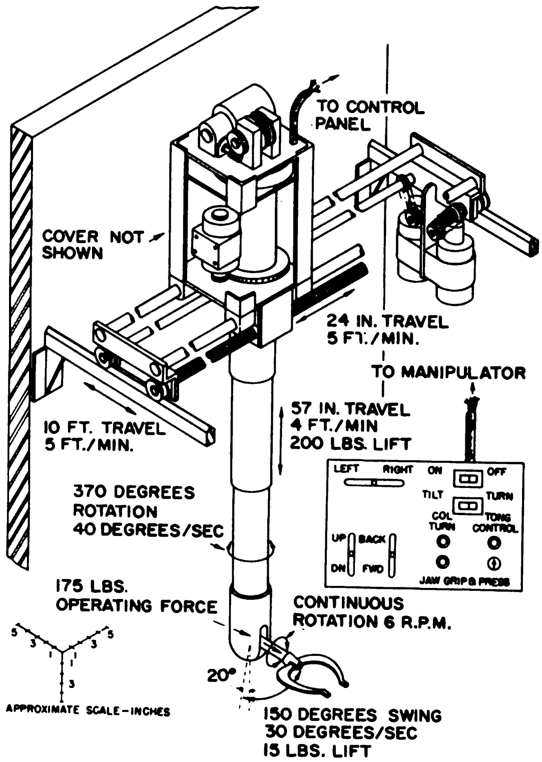


Fig. 2 Manipulator—schematic drawing.

APPLICATION

The electric rectilinear manipulator (Fig. 1) was designed for the handling of radioactive materials in a semihot cell. A telescoping column, with a straight-lift capacity of 200 lb, permits the removal of the covers and contents of pigs located in a recessed well. The manipulator can also perform such delicate operations as sliding the counterweight on a pan balance.

DESCRIPTION

The main carriage (Fig. 2) is moved laterally on rails by an electric motor-driven pinion which engages a rack parallel to the rails. A second motor on the main carriage drives the horizontal lead screw, moving the upper head to the front or rear of the cell. Other motors control column rotation, the raising and lowering of the lower head, wrist tilt, and tong rotation. An air cylinder located at the end of the tong mount closes the tong jaws.

All controls are mounted on a control-box panel and are arranged to duplicate the direction of manipulator movements. Speed and direction of each motion, except the grip, are controlled by separate variacs. Cams on the variac

shafts operate the reversing relays and motor switches.

OPERATION

Movement of the controls loads torsion or compression springs, providing the operator with a synthetic force reflection, or a sense of feel, that is approximately proportional to the applied voltage. The springs also function as a safety device by returning the variac to zero voltage upon release of the control handle. A regulator and three-way valve control the air cylinder actuating the tong jaws. A pressure gauge with special scales indicates safe operating pressures for the handling of various materials.

REFERENCE DATA

Location: Brookhaven National Laboratory.

PLUG-IN MASTER-SLAVE MANIPULATOR

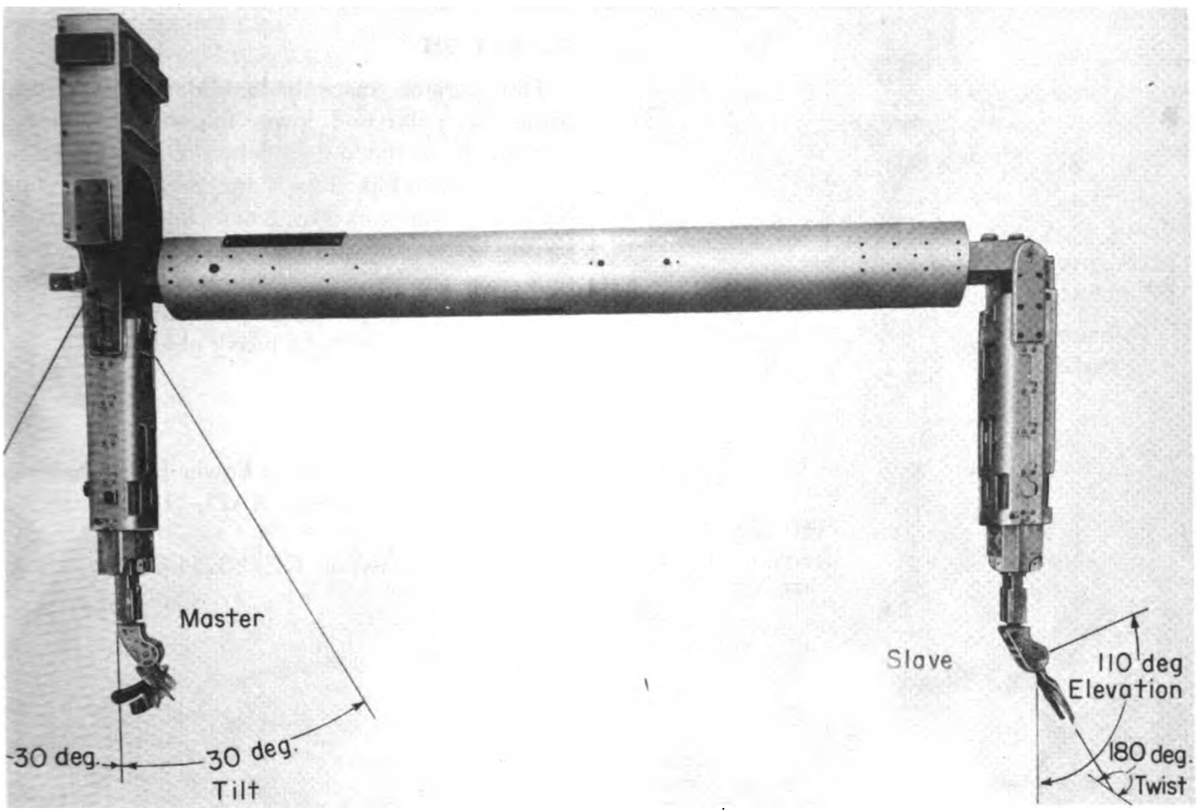


Fig. 1 Side view of plug-in manipulator showing available motions.

APPLICATION

The plug-in master-slave manipulator, referred to as GE-Man-I manipulator, is for use in intermediate and high-level shielded enclosures. The performance and handling characteristics are similar to the model 8 master-slave manipulator (see page 123). It may be easily plugged into or removed from a shielded enclosure without access to the inside of the shielding and has some of the mobility and versatility of a portable manipulator.

DESCRIPTION

All motions in this design have a 1:1 force and motion correspondence between the master and slave ends. For installation or removal, the slave arm is raised to the horizontal position in line with the through-wall tube. A pair of these manipulators can be removed from one operating location and installed in a second location within 2 hr. One complete assembly weighs approximately 450 lb and may be moved from one location to another by a fork truck or a special dolly.

This particular design was made for an installation with the through-wall tube center line at 90 in. above the floor and a wall thickness of 3 ft. For installation and removal of these units, horizontal clearances of 3½ ft inside and 10½ ft outside the shielding are required. The operating headroom needed on the master side of the unit is 26 in. above the center line of the through-wall tube. A pair of these manipulators will effectively cover a 48-in.-square table top 40 in.

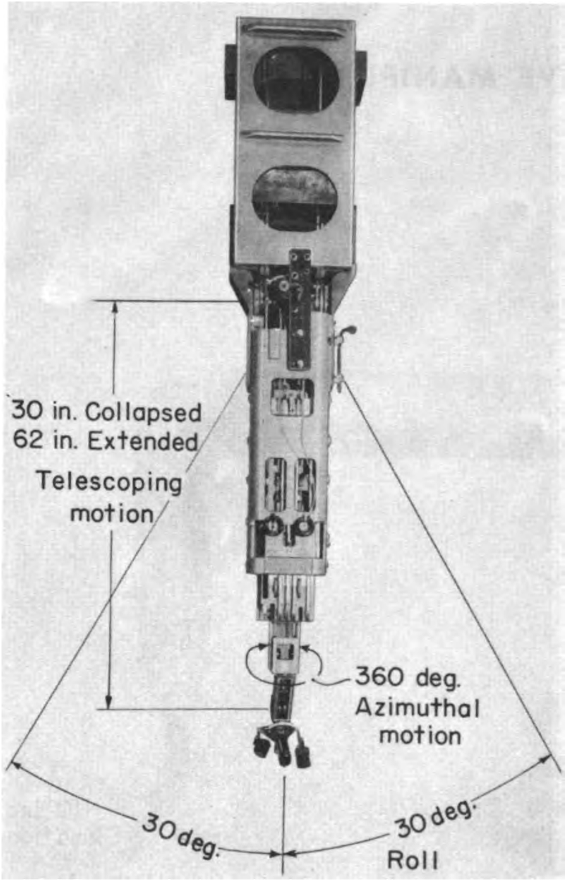


Fig. 2 End view of master side showing additional motions.

above the floor. Figures 1 and 2 show the limits of travel of the various motions of the manipulator.

OPERATION

The operator grasps the handle with one hand, using the palm and lower fingers for general movement of the manipulator and the thumb, index, and middle fingers for the squeeze motion. Manipulators are generally used in pairs having right- and left-hand handles. One manipulator can cooperate with and aid the other in getting a suitable grasp or orientation on the object or help in lifting a heavy object.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.

Reference Document: KAPL-1130, May 20, 1954.

Reference Drawing: GEM-3254-D.

ELECTRONICALLY CONTROLLED MASTER-SLAVE MANIPULATOR ANL MODEL 2

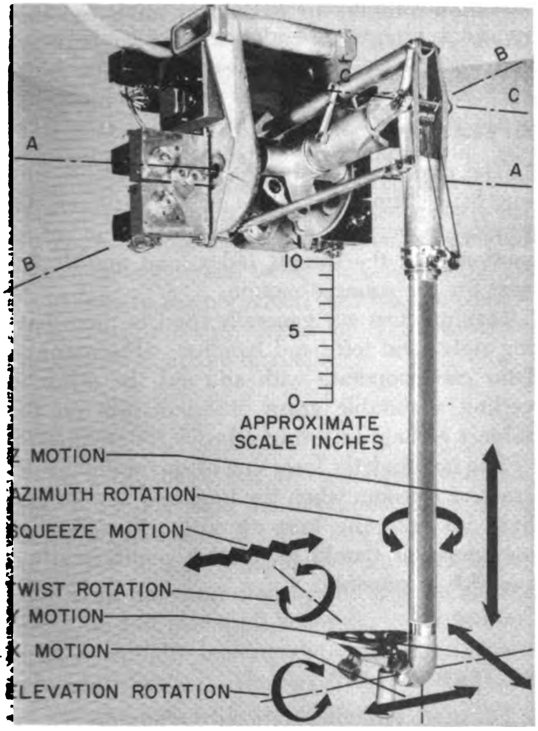


Fig. 1 Master-control-arm assembly.

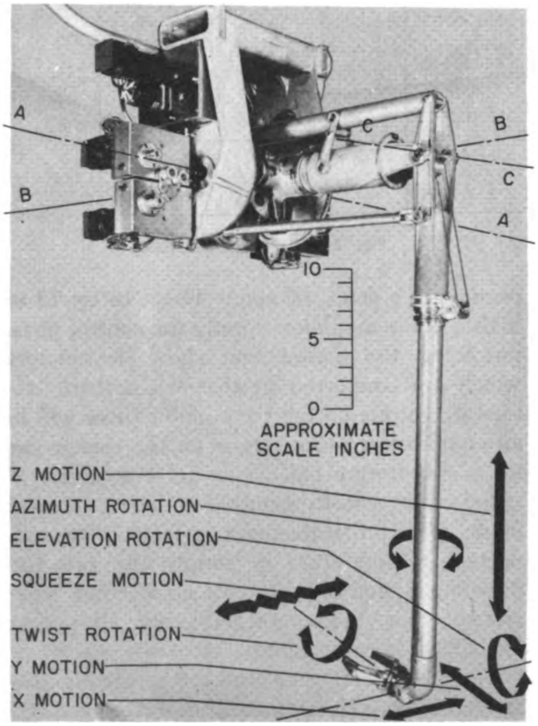


Fig. 2 Slave-arm assembly.

APPLICATION

This manipulator is suitable for carrying out moderately delicate manipulations and handling operations in shielded enclosures. It will exert a force of 8 to 10 lb in any direction. The slave arm is normally mounted on a carriage to cover the desired volume within the shielded enclosure. Likewise, the similar master arm is mounted on another carriage to index it to the desired operating position. The shielded enclosure may be as large as is compatible with viewing. Since the slave arm is controlled entirely by a multiple-conductor cable, the shielded enclosure may be sealed to any desired degree. The maximum exposure to radiation is limited to 10^7 or 10^8 r because of radiation damage to the lubricants and insulation.

DESCRIPTION

The manipulator consists of three major parts: the master-control-arm assembly (Fig. 1), the slave-arm assembly (Fig. 2), and the electronic servoamplifiers (not illustrated). A force-reflecting servo system is used to maintain positional synchronism between the master and slave arms. A two-phase low-inertia motor with integral tachometer is used to drive each motion of both master and slave arms. Each of these motor gearbox assemblies is easily removed for replacement or repair. The rotational motions at the wrist joint and the tong motion are actuated by stainless-steel cables running to drums on the gearbox assemblies.

The seven electronic amplifiers and power supply are mounted in two standard relay racks

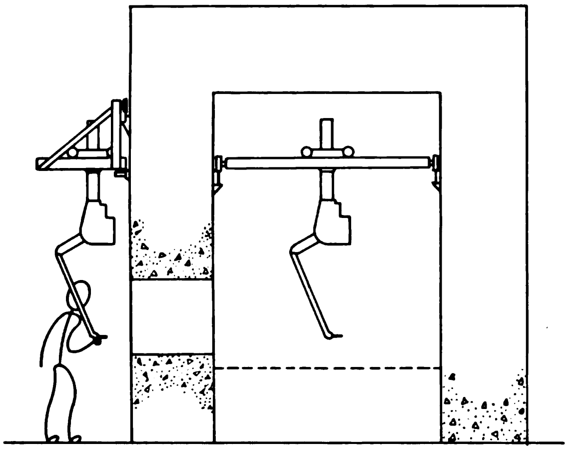


Fig. 3 Typical installation.

occupying a space of about 40 by 18 by 72 in. high. These amplifiers supply the control phase power to the master and slave servomotors, which are connected so that when there is a forward torque on the slave motor there will be an equal and reverse torque on the master motor. This torque balance is quite good for all speeds from zero to about 36 in/sec at the wrist joints. Integral tachometer generators are connected in opposition to supply the principal damping signal for the force-reflecting servo system. The system is stable for all passive loads from zero to infinity.

The master and slave arms are nearly identical mechanically. Exceptions are the handle on the master arm, the tongs on the slave arm, and the gear ratio of the squeeze motion on the slave arm, which is nearly double that of the master arm. The different gear ratio gives a force multiplication of about 2:1 for gripping. The master and slave arms each have seven independent motions. The extent of the motions are as follows: axis *AA* up 45°, down 135°; axis *BB* ± 45°; and axis *CC* ± 45°; azimuth rotation ± 170°; elevation rotation up 20°, down 110°; twist rotation ± 180°.

OPERATION

The operator simply grasps the handle with one hand, using the palm and lower fingers for general movement of the manipulator in its six motions and the thumb, index, and middle fingers for the squeeze motion.

Manipulators are generally used in pairs having right- and left-hand handles. One manipulator can cooperate with and aid the other in getting a suitable grasp or orientation on the subject or help in lifting a heavy object.

The manipulator loses one of its rotational degrees of freedom when the tong and handle axis lines up with the azimuth axis. Handling or manipulation should avoid this zenith position as much as possible.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Manipulator, RCD-406; tongs, RCD-393 or RCD-447.

MECHANICAL MASTER-SLAVE MANIPULATOR ANL MODEL 8

APPLICATION

This is a general-purpose manipulator of the master-slave type suitable for use in intermediate- and high-level shielded enclosures. It enters the shielded enclosure through an 8½- to 10-in. hole or slot in the front wall. The slave wrist joint is designed to accommodate a contamination-control boot and remotely removable tongs. Angular indexing of the slave arm toward or away from the master arm provides extended volume coverage, and when the slave arm is indexed fully to the horizontal position, the manipulator may be readily removed. Load capacity is about 20 lb in any direction.

DESCRIPTION

The manipulator has seven independent motions (Fig. 1), three for rotational orientation, three for movement in space, and a squeeze motion. The *X* and *Y* motions of the master and slave arms are connected by the horizontal support tube and push-pull boom guides of the two arms, essentially making the two arms operate in a parallelogram. The slave arm, however, can be indexed out of parallelism with the master arm by an electromechanical actuator. The *Z* motion is accomplished by telescopic movement of the slave arm and movement of the master arm between the counterweight tubes. Synchronism in this motion is accomplished by using metal tapes over suitable pulley arrangements.

The elevation, twist, and tong motions are connected by metal tapes (Fig. 2), and the azimuth motion is transmitted by stainless-steel cables. Spur gearing is introduced in the wrist joint to reduce tape loading, with a resultant increase in load capacity and a reduction in elasticity in elevation and twist rotation.

Friction is held to a minimum by using ball bearings for all major motions and crowned pulleys for the metal tape. The manipulator is balanced by three counterweights, one on each side of the master boom and one located at the top of the master-boom assembly which is always

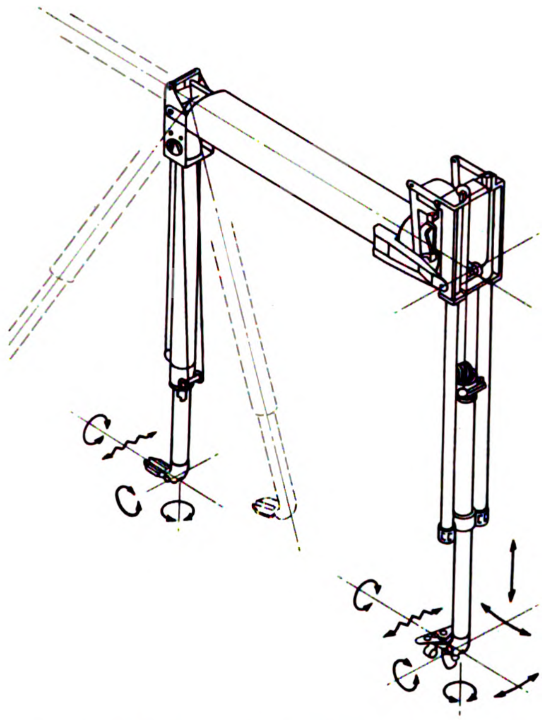


Fig. 1 Schematic of master-slave manipulator showing degrees of freedom.

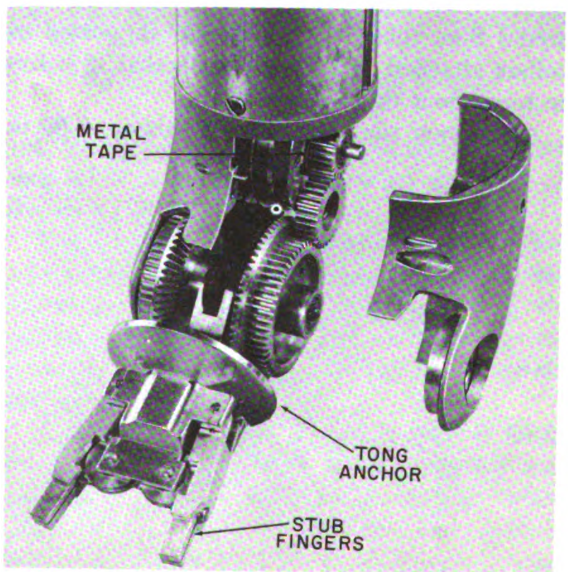


Fig. 2 Wrist joint without boot or tongs.

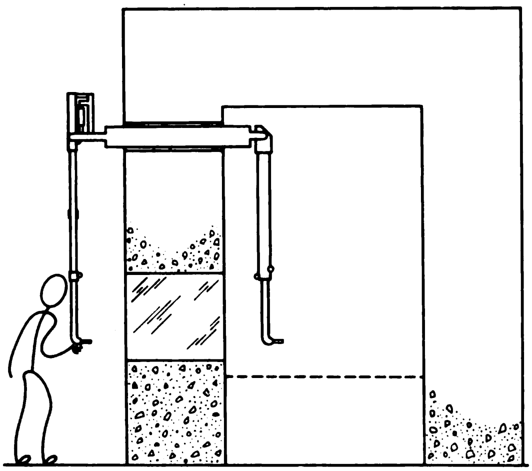


Fig. 3 Typical installation.

kept in synchronism with the slave arm. When the master and slave arms are parallel, the balance is within a few ounces and will be only slightly disturbed when the slave arm is indexed out of parallelism with the master arm up to about 30°. When the slave arm is indexed to the horizontal position, the unbalance becomes greater, but the manipulator is inoperative in such a position and this unbalance is not disturbing.

The *Y* motion of the manipulator is transmitted from master to slave by the main horizontal 8-in. tube which must be supported on rollers attached to the cave such that it is free to turn about this horizontal axis.

A common size for the manipulator is 60 in. for dimension *A* (Fig. 1) and 89 in. for dimension *B* with the boom fully extended in the *Z* motion. These dimensions may be altered somewhat to accommodate a particular installation without seriously limiting performance. The tongs are remotely removable by inserting them into a special fixture.

OPERATION

The operator simply grasps the handle with one hand, using the palm and lower fingers for general movement of the manipulator in its six motions and the thumb, index, and middle fingers for the squeeze motion.

Manipulators are generally used in pairs having right- and left-hand handles; one manipulator can cooperate with and aid the other in getting a suitable grasp or orientation on the object or help in lifting a heavy object. A typical installation is shown in Fig. 3.

The manipulator loses one of its rotational degrees of freedom when the tong and handle axis lines up with the azimuth axis. Handling or manipulation should avoid this zenith position as much as possible.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: R. C. Goertz, Mechanical Master-slave Manipulator, *Nucleonics*, **12** (11), 46 (1954).

Reference Drawings: Manipulator, RCD-371; tongs, RCD-393 or RCD-447.

MECHANICAL MASTER-SLAVE MANIPULATOR ANL MODEL 7

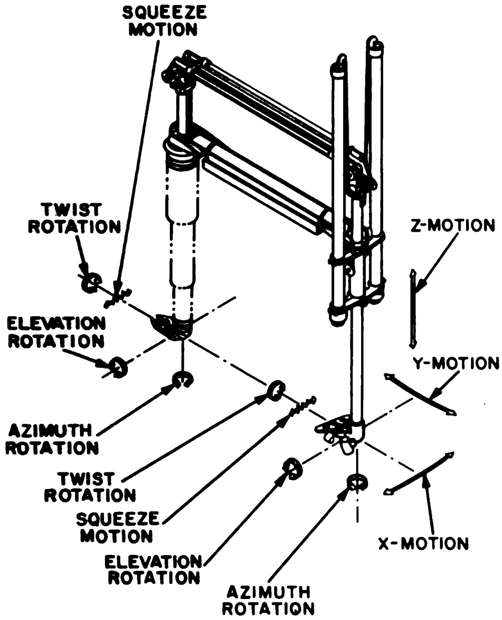


Fig. 1 Illustration of manipulator's seven independent motions.

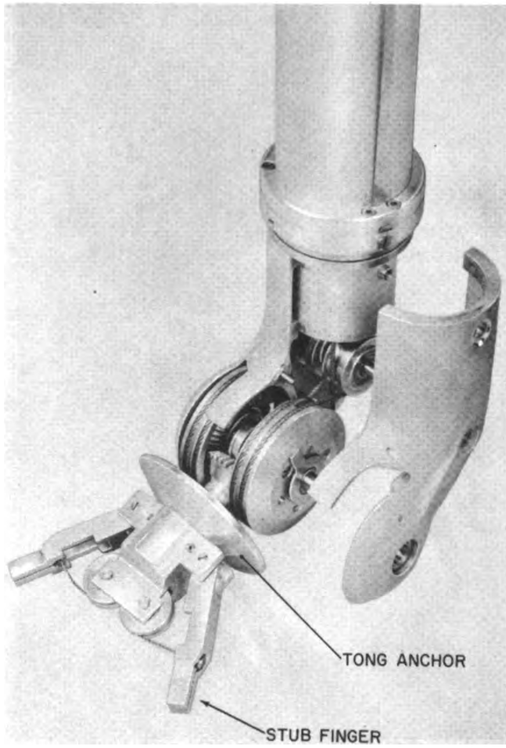


Fig. 2 Wrist joint without boot or tongs.

APPLICATION

This is a general-purpose manipulator of the master-slave type most suitable for junior-cave and intermediate-level shielded enclosures. It enters the shielded enclosure through a hole in the roof; the resulting scatter radiation may be a limiting factor. The manipulator is capable of being booted for contamination control and has remotely removable tongs. Load capacity is about 10 lb in any direction.

DESCRIPTION

The manipulator (Fig. 1) has seven independent motions: three for rotational orientation, three for movement in space, and a squeeze motion. The design is intended to be moderately simple and reliable and yet yield high performance. The positional movements are achieved by parallelogram coupling of the master and slave arms. The Z motion is provided by tapes; the wrist rotational motions and the tong squeeze use stainless-steel cables. Moderately low friction is achieved by using ball bearings for all the major movements.

The manipulator has a counterweight on each side of the master arm which keeps the unit balanced within a few ounces regardless of the position of the manipulator. The tongs are remotely removable by means of a special fixture.

A common size for the manipulator is 40 in. for dimension *A* and 46 in. for dimension *B* with the boom fully extended in *Z* motion. These dimensions may be varied somewhat to suit the particular installation without seriously limiting the performance of the manipulator.

X motion must be provided by rollers which

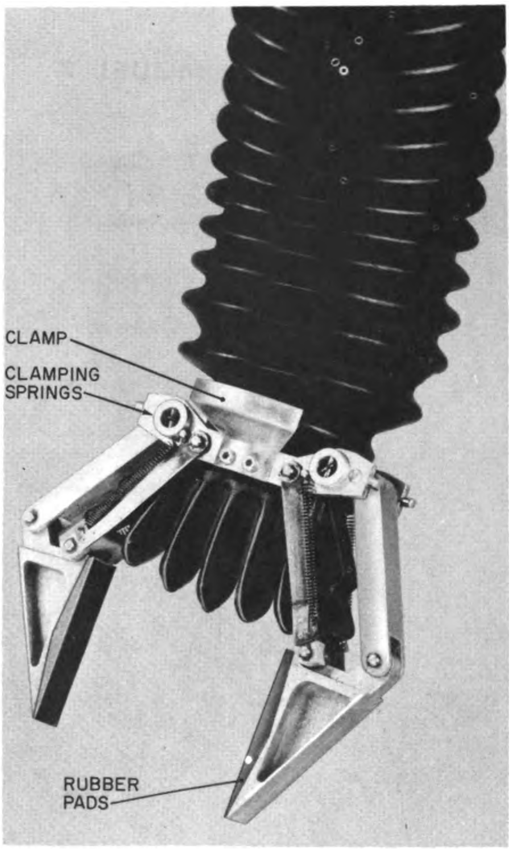


Fig. 3 Booted wrist joint with tongs.

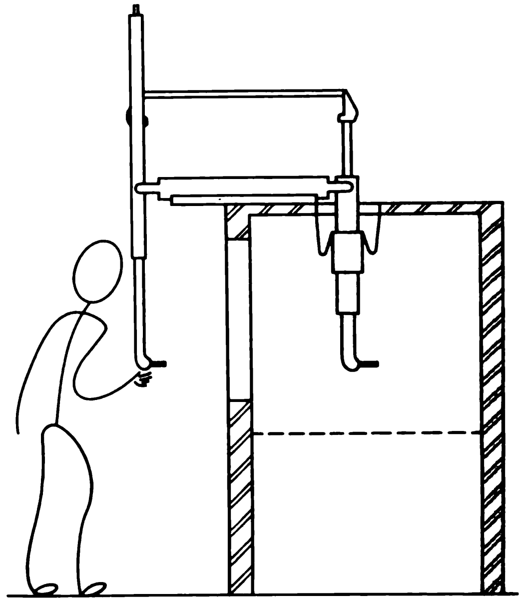


Fig. 4 Typical installation.

support the manipulator. These rollers are generally attached to a channel.

OPERATION

The operator simply grasps the handle with one hand, using the palm and lower fingers for general movement of the manipulator in its six motions and the thumb, index, and middle fingers for the squeeze motion.

Manipulators are generally used in pairs having right- and left-hand handles; one manipulator can cooperate with and aid the other in getting a suitable grasp or orientation on the object or help in lifting a heavy object.

The manipulator loses one of its rotational degrees of freedom when the tong and handle axis lines up with the azimuth axis. Handling or manipulation should avoid this zenith position as much as possible.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Manipulator, RCD-206; tongs, RCD-393, RCD-447.

MECHANICAL ARM

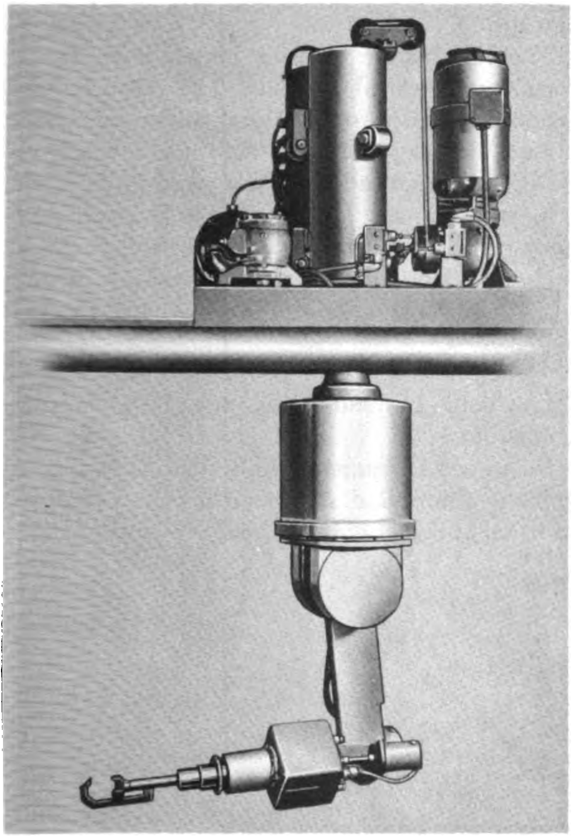


Fig. 1 Mechanical arm with crane bridge, carriage, and vertical telescoping column.

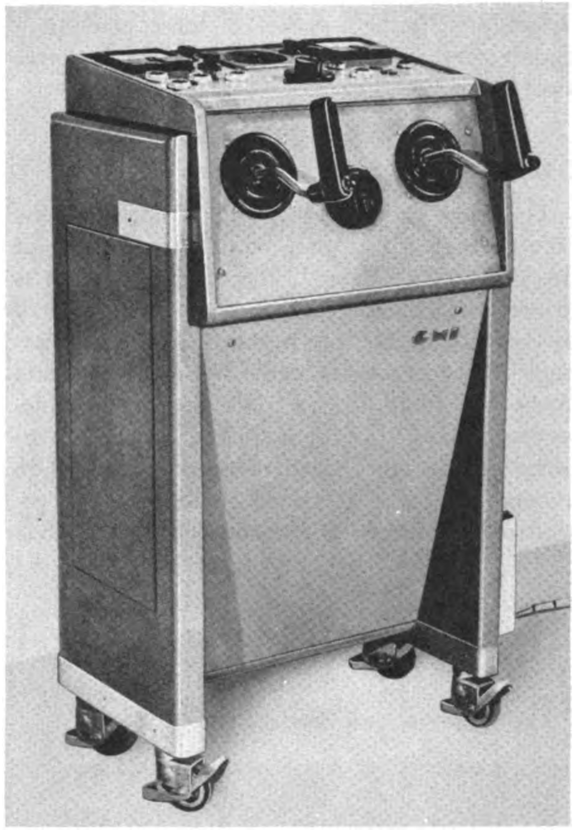


Fig. 2 Remote-control unit.

APPLICATION

The mechanical arm model E is a general-purpose heavy-duty manipulator capable of many independent and precisely controlled motions. A wide range of sensitivity permits the handling of fragile glassware or heavy equipment up to 750 lb. Wrist torque is 30 ft-lb, and hand force is 150 lb.

DESCRIPTION

The manipulator consists of a movable crane bridge on which rides a cross carriage suspending a manipulative unit. A longitudinal drive motor is mounted at one end of the bridge, and the bridge rides on two parallel rails mounted on the front and rear walls of the cell. Transverse-drive and vertical-hoist motors, telescoping tubes, and a cable drum are mounted on the cross carriage. Shoulder and elbow joint and shoulder rotation motors are located in the upper housing of the manipulative unit, and two wrist and grip motors are mounted externally on either side of the elbow. A remote-control unit is equipped with pistol-grip control handles, speed control, meters, loudspeaker, and motor circuits.

Two types of remotely interchangeable grip hands permit a variety of objects to be handled. One hand is a pair of spring-loaded parallel jaws used for general-purpose work. The other hand has a hook-and-anvil arrangement for heavy lifting. Meters indicate the gripping force

and wrist torque, permitting the operator to apply forces ranging from a few ounces to several hundred pounds. An alternate method for force indication is provided by an audible system of force pulses. The pulse rate increases proportionately with the increase in force, making it unnecessary for the operator to take his eyes away from the work.

OPERATION

The crane bridge moves longitudinally on the rails through a rack-and-pinion arrangement at the drive end of the bridge. The carriage is driven transversely by a rack and pinion powered by one of the carriage motors. The other carriage motor powers a cable hoist to raise and lower the manipulative unit within the telescoping tubes. Limit switches prevent overtravel of the foregoing motions. The entire manipulative unit is rotated at the shoulder, extended horizontally at the shoulder, or tilted in the vertical axis at the elbow by the action of three motors in the upper housing. The two external motors behind the wrist provide wrist rotation and grip actuation. Slip clutches prevent overload at the upper arm, elbow, wrist, and grip.

The left handle controls longitudinal, transverse, and vertical motion. The right handle actuates the grip, rotates the shoulder and wrist, extends the shoulder, and tilts the elbow. Both aural and visual indicators for wrist torque and grip pressure are located in the control unit. Each motion has a control range of six speeds in each direction.

REFERENCE DATA

Location: General Mills, Inc., Minneapolis, Minnesota.

Reference Document: E. R. Van Krevelen, A Remote Controlled Mechanical Arm, Report: Instrument Society of America, September, 1953.

BRIDGE HYDRAULIC MANIPULATOR

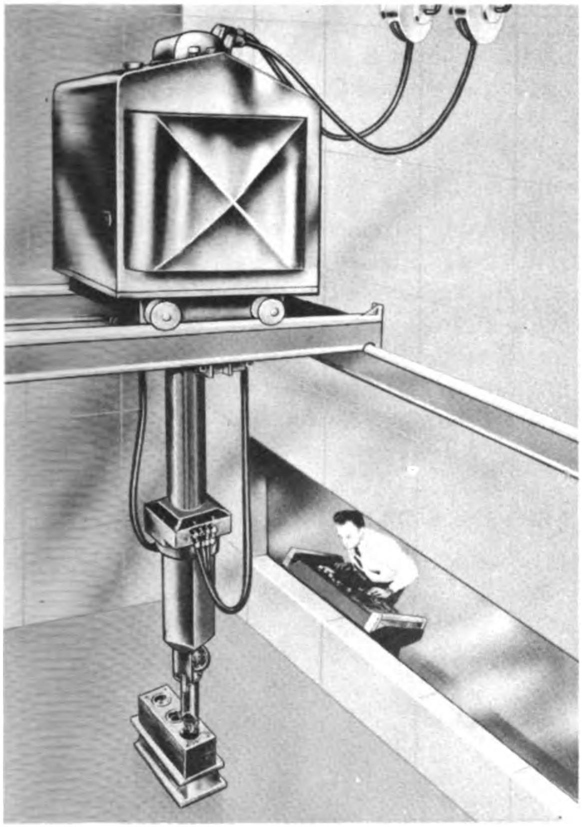


Fig. 1 Bridge manipulator.

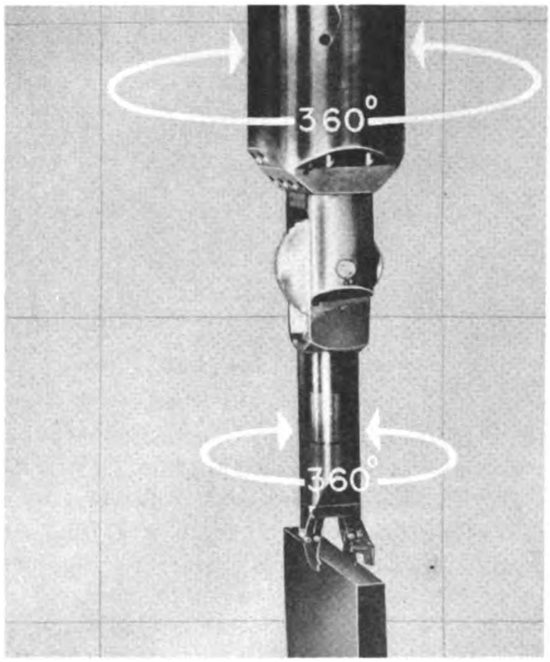


Fig. 2 Upper arm and wrist rotations.

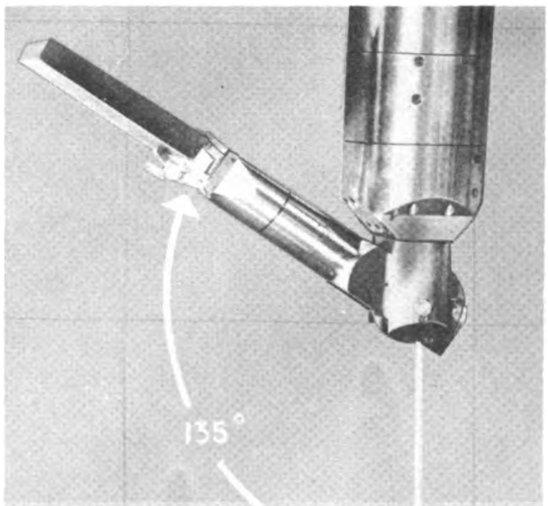


Fig. 3 Elbow actuation.

APPLICATION

The bridge hydraulic manipulator is installed in large-scale hot-laboratory cells to provide remotely controlled manipulation of corrosive, toxic, or radioactive materials. It will lift objects weighing 250 lb.

DESCRIPTION

The hydraulic manipulator (Fig. 1) rides along guide rails which permit a 20-ft longitudinal motion and a 10-ft transverse motion. The hydraulic system and its controls are enclosed within the manipulator housing, which is waterproof and explosion resistant. The vertical motion is 6 ft. The upper arm and wrists (Fig. 2)

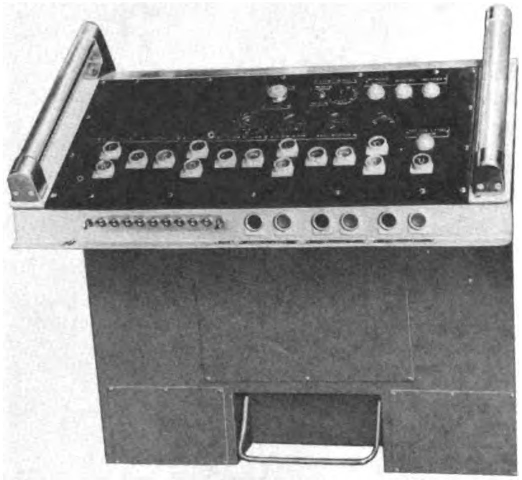


Fig. 4 Control panel.

rotate continuously. Elbow actuation (Fig. 3) is 135° up from the vertical position.

The manipulator has the following interchangeable hands: a jaw with a $2\frac{1}{2}$-in. grip capable of handling fragile objects or applying up to 1500 lb force between the jaws, a bar vise to clamp on a 1-in. bar and lift an object mounted on the bar, and a socket hand which grips any $\frac{3}{4}$-in. tool and exerts a torque of 200 lb-in.

The hydraulic power package is driven by a 220-volt a-c three-phase 35-amp motor. Power for the controls is converted to 110 volts alternating current and 24 volts direct current.

OPERATION

Operation is remotely controlled from a portable panel (Fig. 4) that can be moved along with the location of the manipulator. The panel has indicators and hand or foot speed controls for all motions and a hand tool force indicator. Motions may be controlled to $\pm\frac{1}{32}$ in. for linear motions and $\pm 1°$ for rotation.

REFERENCE DATA

Location: Greer Hydraulics, Inc., Jamaica, New York.

THROUGH-WALL ELECTRIC MANIPULATOR

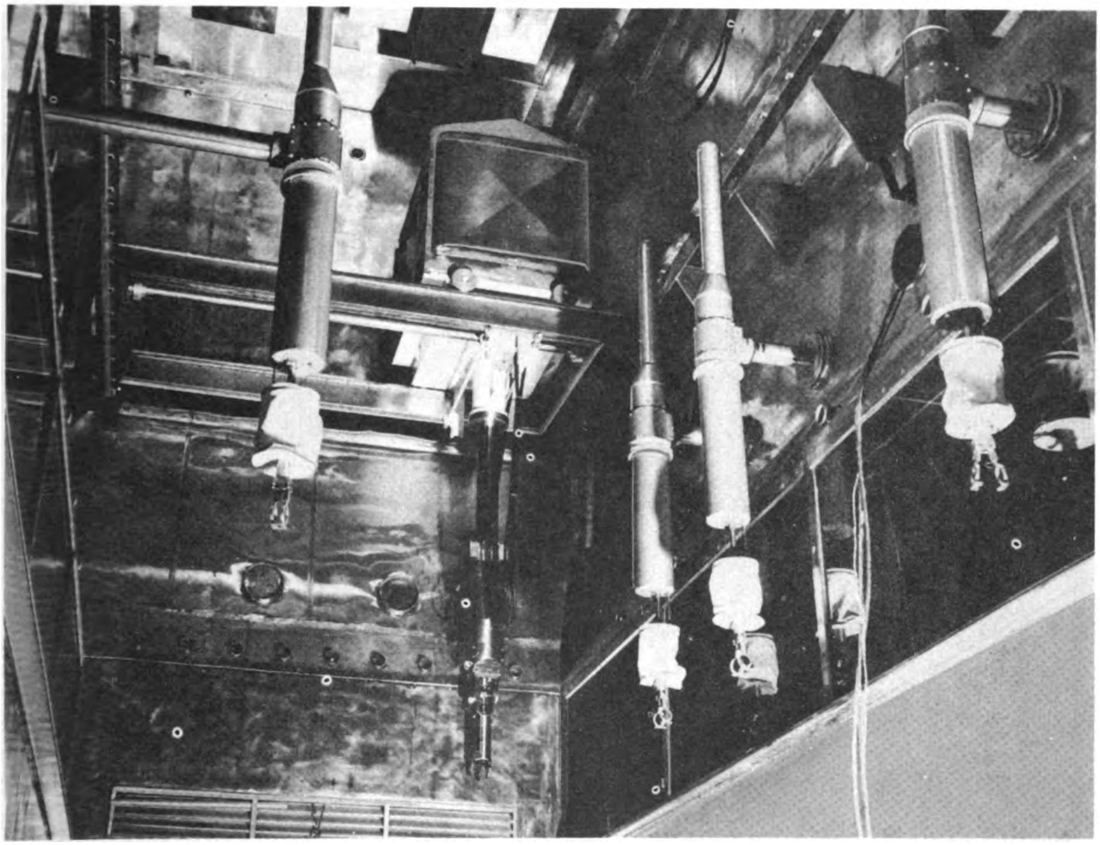


Fig. 1 View of slave end.

APPLICATION

The through-wall electric manipulator is designed for use in hot-cell operations where it is possible to have access to the cell through a hole in its wall. Wall mounting requires a 10-in.-diameter tube, and wall thickness can be up to 6 ft. Vertical lift capacity is 25 lb.

DESCRIPTION

The manipulator has a longitudinal motion of 46 in. and rotates 360° about the tube axis. Vertical travel is 24 in., and rotary action about the vertical axis is 180°. Wrist rotation is continuously servo-motor-driven. Elbow actuation, which is boosted by means of an electric motor, is $\pm 90°$.

Remotely interchangeable hands with various shaped fingers with clamping openings up to 4 in. can be attached to the manipulator. These jaws are actuated by a torque wrench lever that has a 4:1 mechanical advantage.

All motions, except elbow and wrist motions, are mechanically controlled by aircraft cables running over pulleys making a master-slave type of operation. The manipulator can be operated from either a 24-volt d-c supply or a battery pack.

All mechanisms are dust-sealed with metal and silicone rubber boots. The through-wall tube and the wall hole have a 12-in. lead shield.

OPERATION

Motions are electrically or manually controlled. The jaws can be locked in any position and released at the will of the operator. The unit can be rotated 90° and locked in position out of the operator's way.

The manipulator can be disassembled and removed from the wall by means of one simple disassembly union on the main tube.

REFERENCE DATA

Location: Greer Hydraulics, Inc., Jamaica, New York.

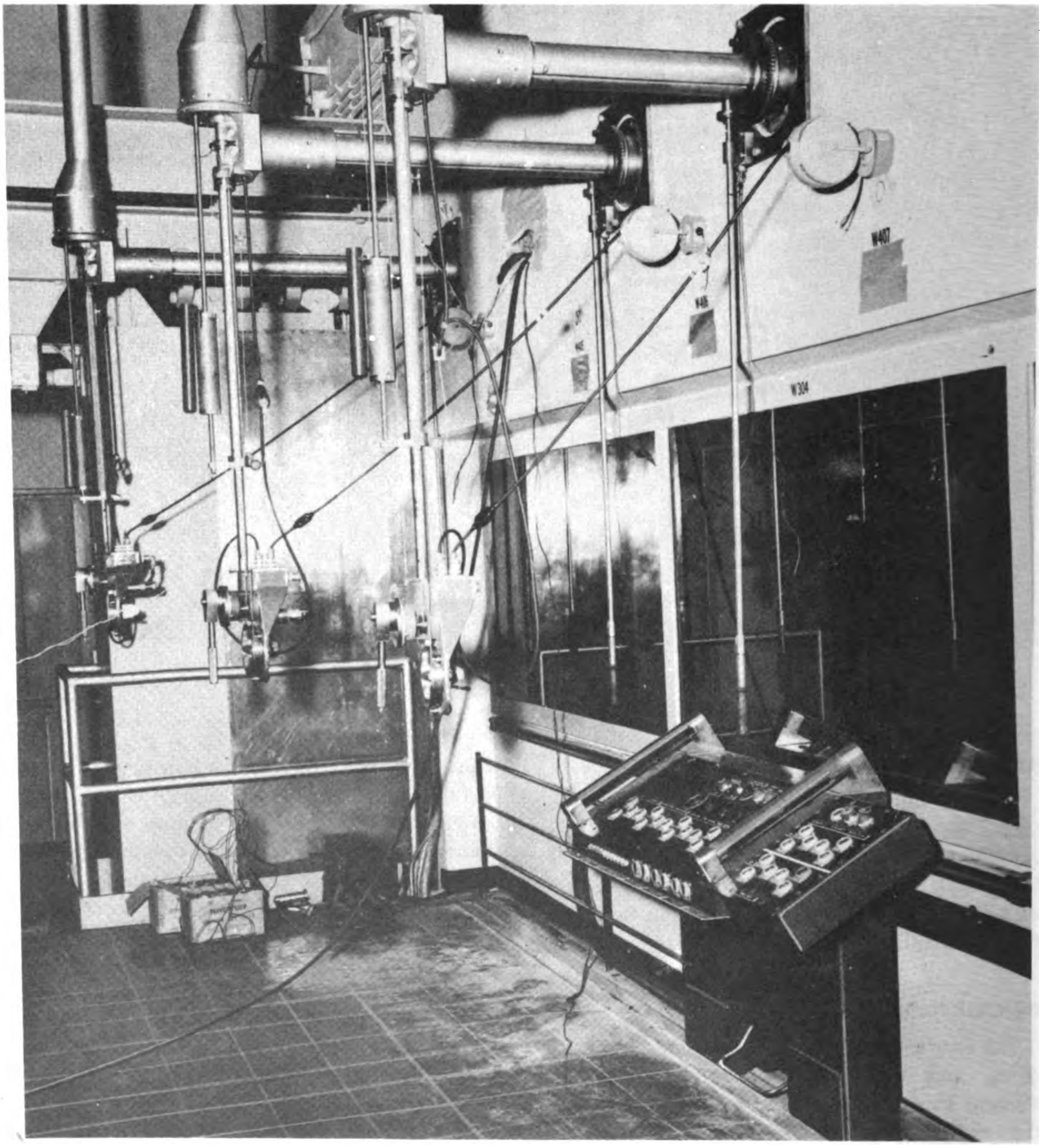


Fig. 2 View of master end.

MECHANICAL-RECTILINEAR MANIPULATOR

APPLICATION

The over-the-wall-type mechanical-rectilinear manipulator was designed to convey bottles of radioisotopes between the storage and transfer areas shielded by a 6-ft-high concrete barricade. The unit is track-mounted on top of a 2-ft-thick shield, and the rectilinear motions of the manipulator allow it to service the entire 45-ft long, 4-ft deep, and 3-ft wide storage and transfer area. The bottle pickup jaws on the manipulator head can accommodate all bottle sizes from 25 to 500 ml.

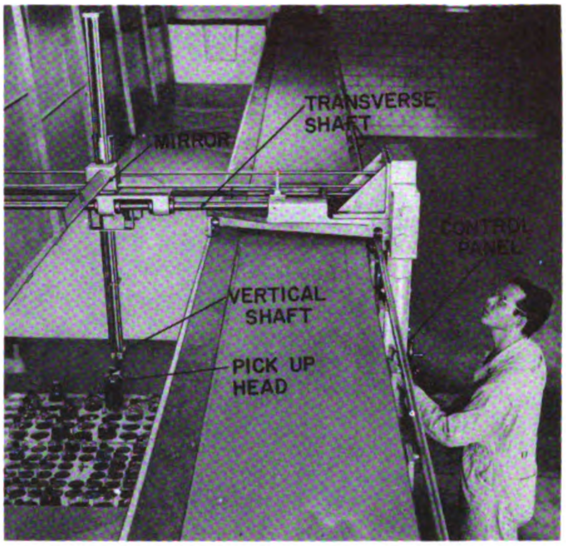
DESCRIPTION

The unit is a mechanical manipulator with all movements manually controlled from the panel suspended below the top of the barricade to a convenient height on the outside. The free-rolling lateral movement of the manipulator may be restricted by the use of a friction brake when removing or replacing bottles. Transverse, vertical, and pickup jaw motions are all controlled by small handwheels actuating a chain drive to produce rotation of the horizontal drive shafts. One shaft, an acme-thread lead screw, produces the transverse motion of the ball-bushing-mounted carriage riding on two cantilever tubes which extend to a point close to the rear wall.

Vertical movement of the pickup-head support tube is obtained by a keyed horizontal shaft driving a worm and gear with an internal nut controlling a threaded vertical shaft. This shaft is attached to the vertical support tube guided also by ball bushings.

Horizontal and vertical keyed shafts with associated gears and cams actuate the pickup jaws for opening or closing. All motions of the manipulator are individually controlled and may be performed simultaneously.

Viewing of the pickup head is obtained by overhead mirrors mounted along the back wall or by a mirror system attached to the manipulator frame and carriage.



OPERATION

With the tong jaws in the full-open position the operator rolls the unit laterally to the approximate position in line with the bottle to be removed from the storage tray. By simultaneously operating the transverse and vertical controls and viewing through the overhead mirrors, the jaws of the manipulator are moved to a position over the desired bottle. Viewing through the manipulator mirror system then allows for finer positioning over the bottle. The head is then lowered until the bottle top is contacted by a "feeler" stop. The jaws are then closed, gripping the bottle below the flanged neck. All contacts with the bottle can be felt through the control system, and the self-locking feature eliminates accidental dropping of containers. In addition, the mechanical advantage requires unusually large control forces by the operator to damage the bottles.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-6102, D-6103, D-6104. D-6105, D-6106, D-6107, D-6108, D-6109, D-6110, D-6111, D-6112, E-6113, C-6114.

MANUAL MANIPULATOR BNL MODEL 2

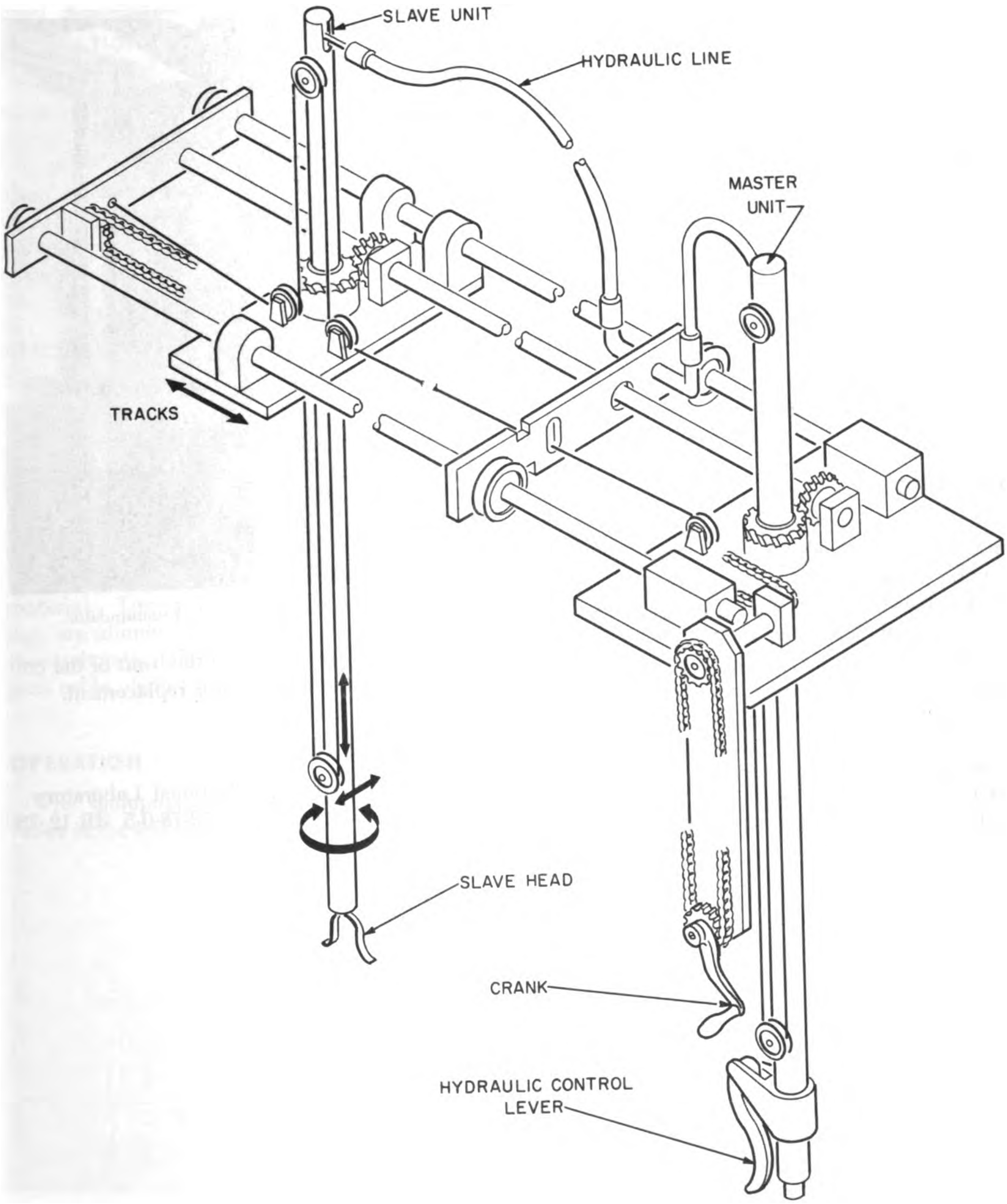


Fig. 1 Model II manipulator—schematic diagram.

APPLICATION

The manual manipulator, model 2, is a manually powered master-slave type of rectilinear manipulator for remote handling of light objects (up to 15 lb) in semihot cells. It is a versatile and relatively low-cost instrument. Its narrow, 6-in. width permits its removal for use in other track-equipped cells.

DESCRIPTION

This device consists of master and slave units that are counterbalanced by Neg'ators (constant-force spring), equipped with a closed hydraulic system (see page 147), and supported on the cross rods of a four-wheel main carriage (Fig. 1). The main carriage rides on horizontal tracks, one track mounted on the front, the other on the rear wall of the hot cell. All exposed parts are of corrosion-resistant material.

OPERATION

Lateral, vertical, and rotary movements of the master column (Fig. 2) cause a corresponding motion of the slave column. Transverse motion of the slave unit along the cross rods is obtained by rotating the hand crank. A hand lever on the master column controls the hydraulic system which actuates the interchangeable head (see page 149) on the slave column. The head can be locked in the "hold" position by turning the lock screw on the master column. The manipulator is removed from the cell by tipping it laterally off its tracks and withdrawing it through the curtained opening along the front of the cell The operation is reversed for replacement.

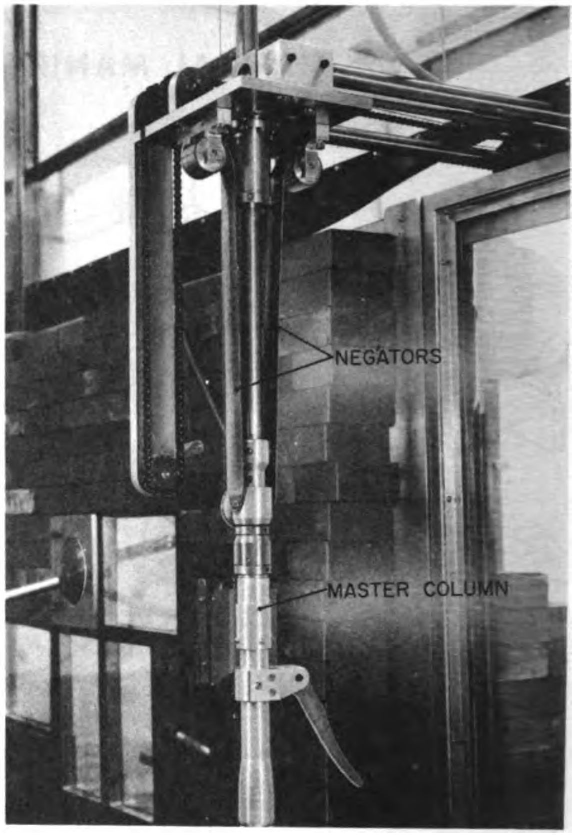


Fig. 2 Master unit—model II manipulator.

REFERENCE DATA

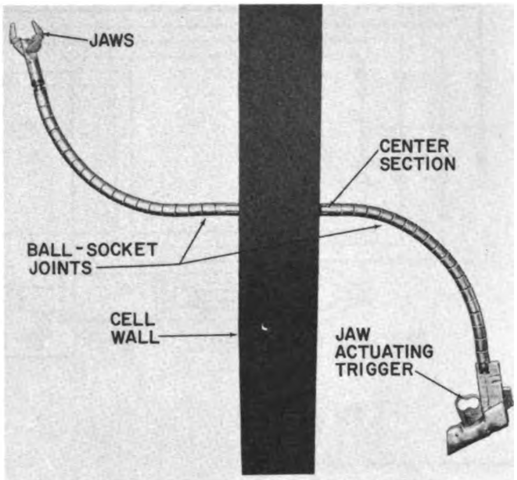
Location: Brookhaven National Laboratory.

Drawing References: RB 12-78-0-5, RB 12-78 56, RB 12-78-54.

EXTRAMAN MANIPULATOR

APPLICATION

Extraman manipulators are designed for performing odd jobs where a remote hand is required. They are capable of operating through 1-in. pipes which penetrate 3-in.-thick cell walls. They have been used for light duty in deep cells, operating successfully in lengths up to 30 ft. Various types and shapes of jaws can be attached to suit the immediate need.



DESCRIPTION

The extraman manipulator operates through a 1-in. pipe and is composed of two series of ball-and-socket joints, forming segmented sections, separated by a straight rigid center section. Sections are held together by six strands of $\frac{3}{32}$-in. stainless-steel aircraft cable threaded through holes in the ball-and-socket segments. The ball-and-socket segments are of a light rigid material. The parallel jaws, 0 to 2½ in. opening, are aluminum or stainless steel as requirements dictate. The jaws are operated by a push-pull cable along the axis of the manipulator.

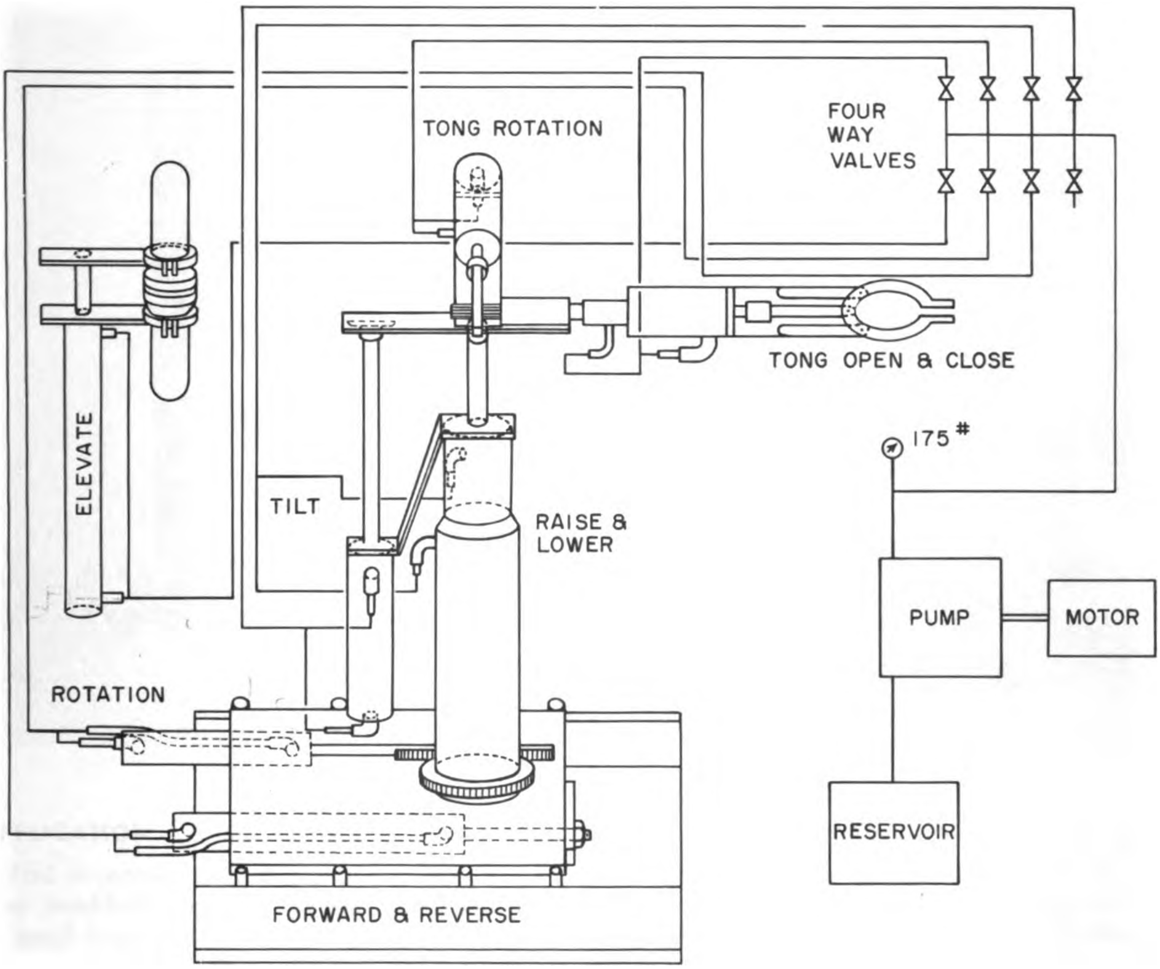
OPERATION

The manipulator is inserted through small holes in the cell wall. The handle is then moved to bring the jaws to the proper position. A movement of the handle moves the jaws to a corresponding movement in the opposite direction. Jaws are opened or closed by opening or closing the grip of the first two fingers of the operating hand. The fingers fit inside a trigger which relays the movement; there are no springs on the 1-in. extraman.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: D-17292.

A REMOTE-CONTROLLED APPARATUS FOR CANNING PELLETS



Schematic diagram of hydraulically operated apparatus.

APPLICATION

This apparatus was designed and constructed to facilitate the remote manipulation of small parts such as polonium-beryllium pellets.

DESCRIPTION

The apparatus consists of hydraulically operated tongs having six different motions. The motions of the tongs are obtained through the use of six double-acting hydraulic cylinders and correspond to finger, wrist, arm, and body movements. In two instances the action of the cylinders is translated into 180° rotary action by racks and pinions. A pressure of 175 psi is supplied to the cylinders by a pump driven at 54 rpm. Flexibility is obtained by the use of polyethylene tubing attached with fittings. Movement of each cylinder is controlled by a three-position reversing valve.

OPERATION

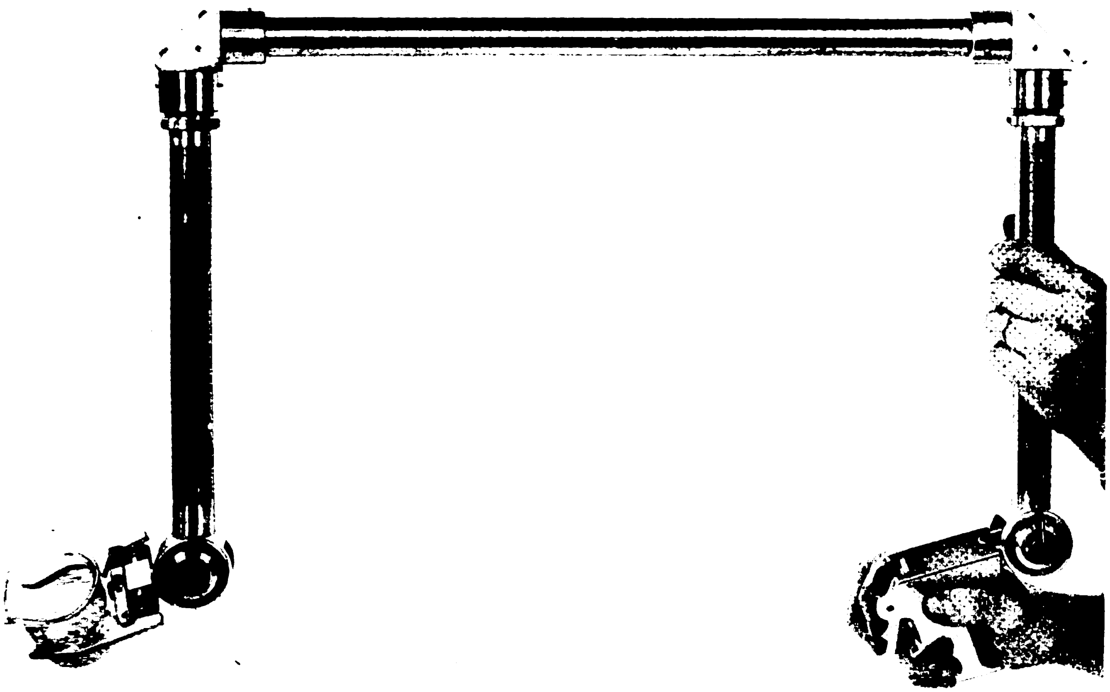
Neutron sources are assembled by the manipulation of the valves which control the cylinders; any movement is reversed merely by reversing the valve.

REFERENCE DATA

Location: Mound Laboratory.

Reference Document: J. L. Richmond, Preparation of Neutron Sources, *Nucleonics,* **12** (11), 88 (1954).

OVER-WALL MANIPULATOR



APPLICATION

This over-wall manipulator is a general-purpose hand-held tool for over-wall manipulation in small brick piles and open-top caves. It is not primarily intended as a sole source of manipulation, but rather as a flexible tool for use where changing conditions during operation present unforeseen handling problems. As such, it is an excellent emergency tool, and it is also valuable in disassembly and cleanup.

DESCRIPTION

The manipulator is constructed of aluminum alloy and is of the inverted U type, with three mechanical motions: wrist swing, wrist rotation, and jaw closure. The slave end may be prepositioned to put wrist swing in the plane of the U frame or up to 90° either side of this plane. Clockwise or counterclockwise wrist rotation is continuous and unlimited. Jaw closure is hydraulic, and the master end includes a hydraulic fluid reservoir in the handle of the manipulator that will add fluid to the system, at the twist of a screwdriver. Water is generally used as the fluid medium. The jaws are readily removed or replaced without affecting the hydraulic system, and a variety of jaw shapes may be fitted. The lengths of the legs of the U frame can be easily changed to suit new applications, although this also requires changing the length of the drive chain and changing the length of the hydraulic tubing.

OPERATION

With the manipulator in place over a wall, the jaws may be closed on the object to be lifted by

squeezing the handle grip. The object can then be swung, lifted, or rotated as desired. The jaws are released by relaxing the pressure on the handle grip.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Drawings: H-7-1016 Sheets 1 to 7; SK-3-6219 Sheet 1.

BALL-SWIVEL MANIPULATOR TONGS

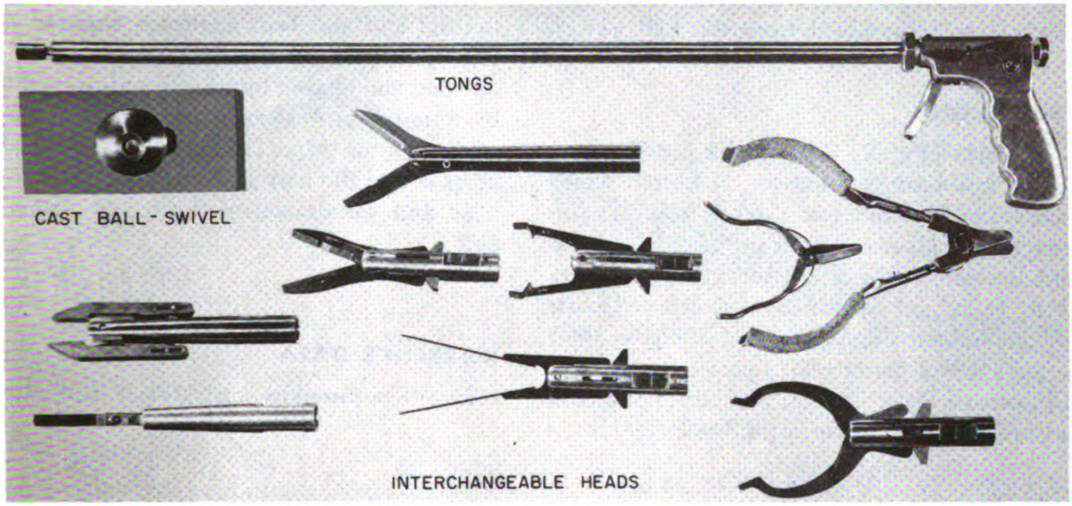


Fig. 1 Ball manipulator tongs and a typical group of interchangeable heads.

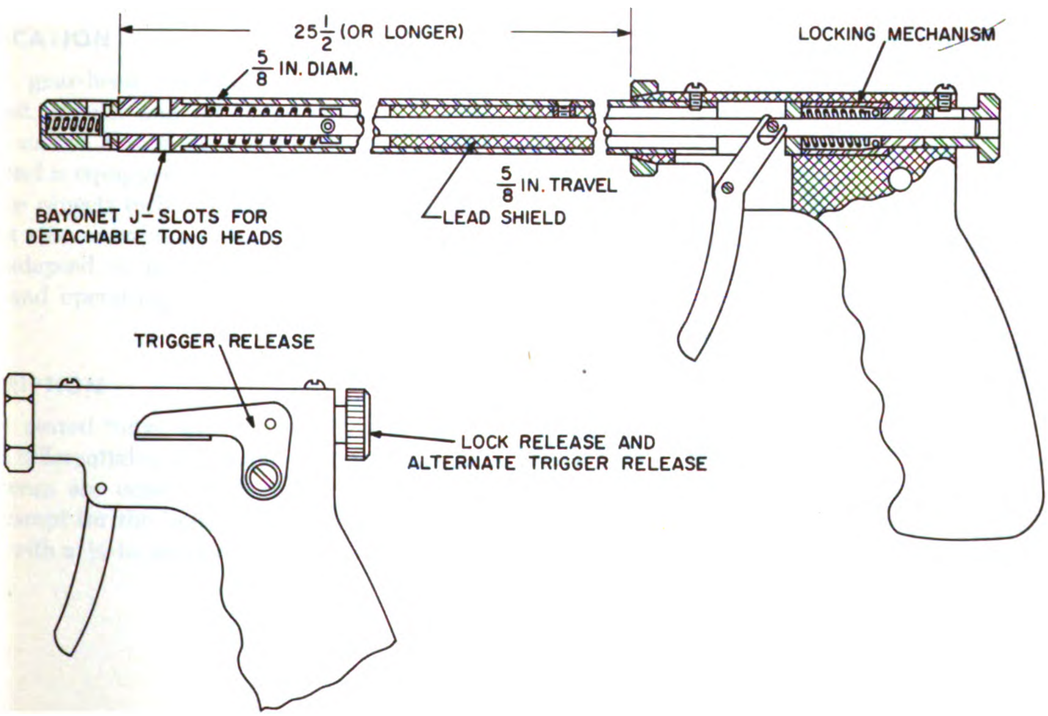


Fig. 2 Tongs mechanism.

APPLICATION

These ball-swivel manipulator tongs are a general-purpose handling device which may be either hand-held or supported by a ball-swivel joint mounted in a protective shield. The design (Fig. 1), adapted for use with detachable heads, permits easy withdrawal from the ball swivel.

DESCRIPTION

The tongs (Fig. 2) consist of a pistol grip, a trigger, and a trigger release. A barrel, which encloses the operating rod, extends from the grip through the ball-swivel joint in the shield to the operating end. Over-all tong lengths range from $2\frac{1}{2}$ to 14 ft, and construction of exposed parts is of aluminum, duralumin, and stainless steel. The ball swivel permits 65° operation and takes up the space of an integral number of standard lead bricks for inclusion in the brick shield.

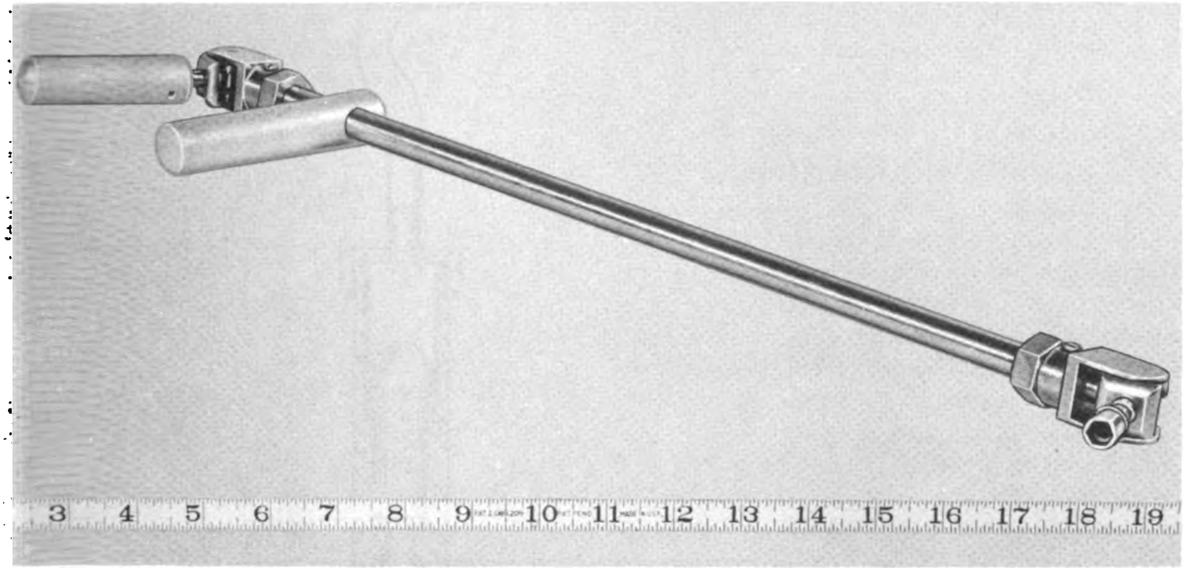
OPERATION

When the trigger is squeezed, the operating rod is driven forward to actuate the interchangeable head (see page 149) and is automatically locked in this extended position by the thrust of a spring-loaded collar of balls, which ride on the rod and also bear against a tapered barrel, until unlocked by the trigger release. Direct opening and closing by trigger action is obtained by disengaging the collar by means of the lock release on the grip. Bayonet J slots at the operating end of the barrel permit detachment of the head and withdrawal of the tongs through the ball.

REFERENCE DATA

Location: Brookhaven National Laboratory.

GEAR-HEAD MANIPULATOR



Gear-head manipulator before insertion in ball-socket fixture.

APPLICATION

The gear-head manipulator is designed to transmit angular and rotational motion through a ball-socket fixture in a shielding wall. The slave end is equipped with a socket-head wrench, and the objects to be turned are fitted with the correct size acorn nut. These tongs are particularly adapted to bolting and unbolting equipment and operating valves.

DESCRIPTION

The geared tongs are of tubular construction with a differential-gear arrangement on each end. The tongs are constructed entirely of stainless steel except for the brass gears. The tool end is fitted with a ¼-in.-square snap-on fitting to take a standard socket-head wrench. The barrel is 22 in. long and ⅝ in. in diameter.

OPERATION

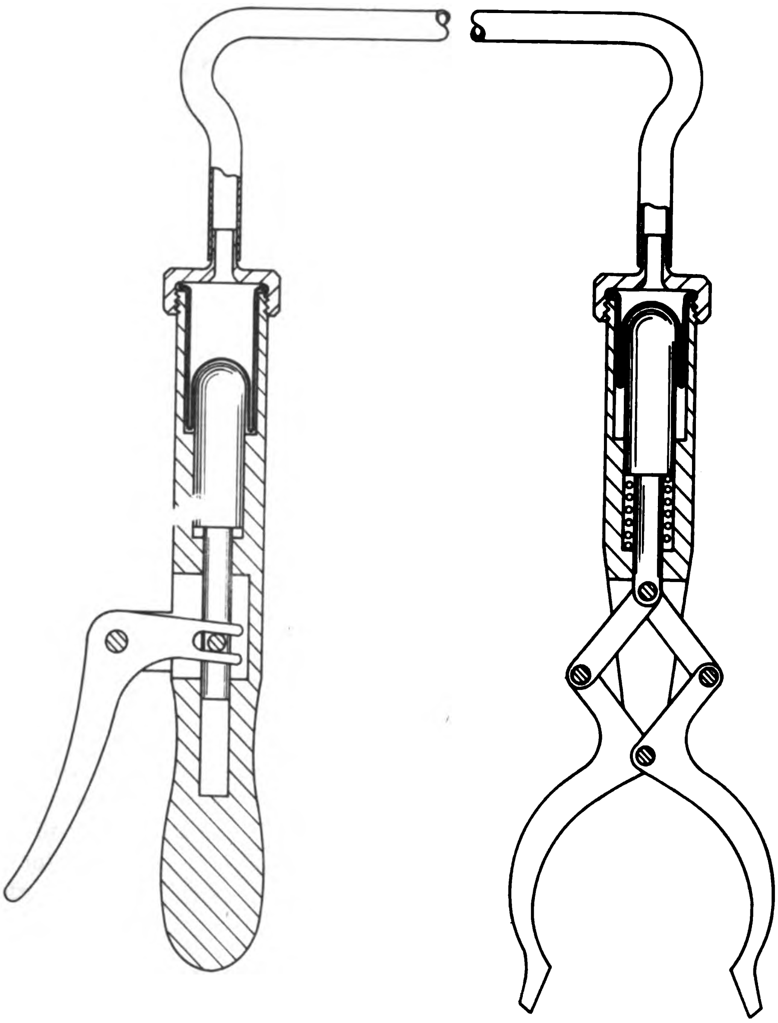
First the tongs are positioned at the correct angle by movement of the manipulator ball in the socket. The slave end is then aligned with the object to be turned by movement of the master handle. The rotational motion may then be accomplished by turning the master handle.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawings: Assembly W-160828; Details D-113241, D-113242, D-113338, D-113246.

HYDRAULIC ACTUATING MECHANISM



Hydraulic system—schematic diagram.

APPLICATION

This manually powered hydraulic system is used to actuate the operating head of a remote handling device in hot-cell operations. It may be applied to straight tongs, articulated tongs, master-slave manipulators (see page 135), and other devices. Since frictional losses in the hydraulic system are low, the operator benefits from accurate tactile response.

DESCRIPTION

The system consists of a hand lever fixed to the remote handle and mechanically linked to a round-head piston. The piston is in contact with a diaphragm (industrial heavy-duty latex finger cot) within an aluminum cylinder. The cylinder is equipped with a removable screw cap tapped with a nipple fitted to a flexible polyethylene tube. This tubing contains the hydraulic fluid

(water) and terminates at a second aluminum cylinder containing a diaphragm and piston.

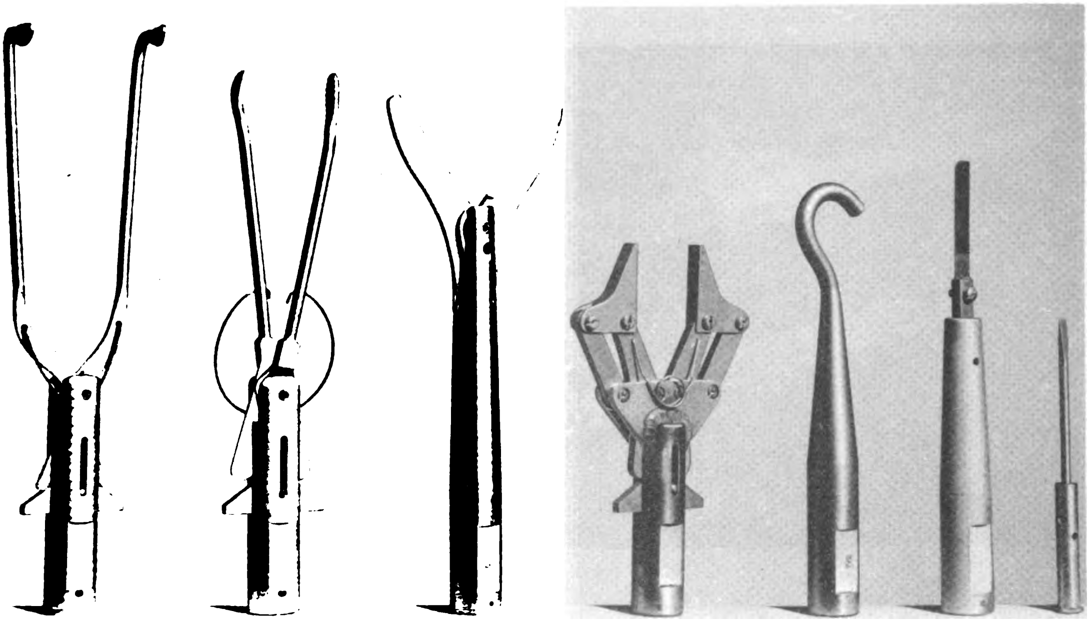
OPERATION

The hand lever is pressed to advance the piston against the diaphragm, exerting pressure on the fluid. Pressure is transmitted through the Tygon tubing to the piston at the operating end, advancing the piston rod and actuating the head. When the hand lever is released, the system is returned to its initial condition by the action of the return spring.

REFERENCE DATA

Location: Brookhaven National Laboratory.

INTERCHANGEABLE HEADS FOR REMOTE-HANDLING DEVICES



Representative group of interchangeable heads. Other types are shown on page 143.

APPLICATION

Interchangeable heads or jaws are designed to facilitate diversified handling and specialized procedures in hot-cell operations. They are standardized for interchangeable attachment to manipulators, straight tongs, and articulated tongs.

DESCRIPTION

Interchangeable heads, ranging in length up to 8 in., are constructed of stainless steel and include grasping and cutting devices of various sizes, angles, and surface characteristics such as pincers (see Fig. 1, page 143), forceps, tweezers, clamps, snips, and scissors. Also included are a lifting hook, screwdriver, and saw. Each head has a hollow collar which may be locked to the manipulator or tong shaft by means of pins in a bayonet J slot.

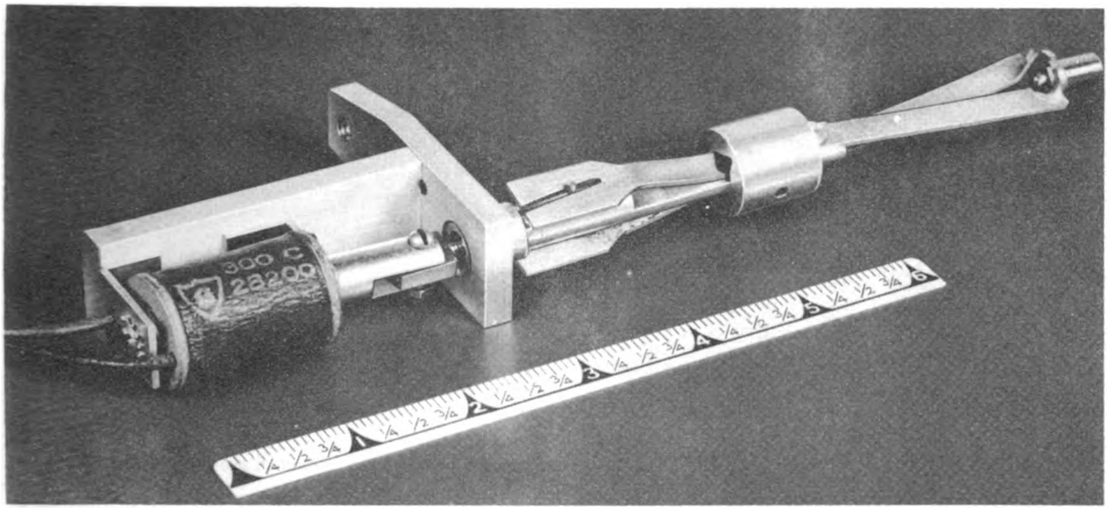
OPERATION

The required head is inserted, by hand or remotely, in the collar over the shaft and rotated a quarter turn to lock it in place. The head is removed by reversing this procedure. The grasping and cutting heads are closed by pantographic actuation when the shaft is advanced. In these types of heads the normally open position is maintained by a return spring when the shaft is retracted. The hook, saw, and screwdriver heads function as extensions of the shaft only and may be extended, retracted, and rotated. When not in use, heads are stored in a conveniently located rack within the cell, and can be changed either manually or remotely.

REFERENCE DATA

Location: Brookhaven National Laboratory.

SOLENOID-ACTIVATED TONGS



APPLICATION

These solenoid-activated tongs were designed to grasp and hold a ¼-in.-diameter crucible for insertion into and removal from a hole ¾ in. in diameter and 3¼ in. deep. Although designed for vertical operation, minor modification of the tong assembly will permit operation in any position. Different sizes and shapes of crucibles may be accommodated by using different tong jaws.

DESCRIPTION

The principal features are shown in the illustration. The solenoid is a standard commercial unit, operated by 110 volts alternating current, and has an armature travel of ½ in. The jaws open and close with a scissorlike action and are actuated by a pin moving in oblique slots in the upper jaw ends. This pin is inserted in an actuating rod connected to the solenoid armature. The closing force is supplied by a weight.

OPERATION

When the tongs are in a vertical position, the weight holds the tongs closed. Passing current through the solenoid pulls the actuating rod up, opening the jaws. Vertical movement of the tongs is obtained by means of a rod runner or manipulator.

REFERENCE DATA

Location: Mound Laboratory.

AUXILIARY PLUG-IN FINGERS FOR MASTER-SLAVE JAWS

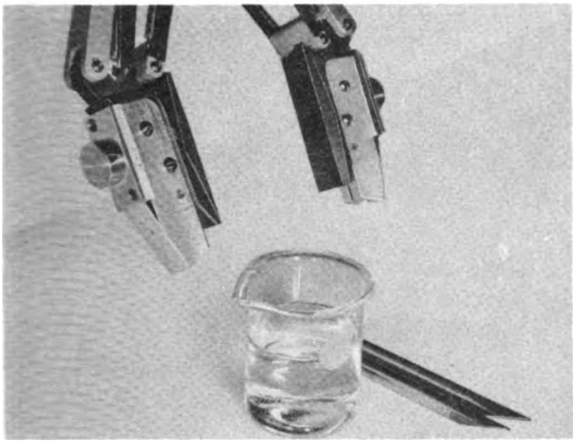


Fig. 1 Fixtures for plug-in fingers mounted on manipulator jaws.

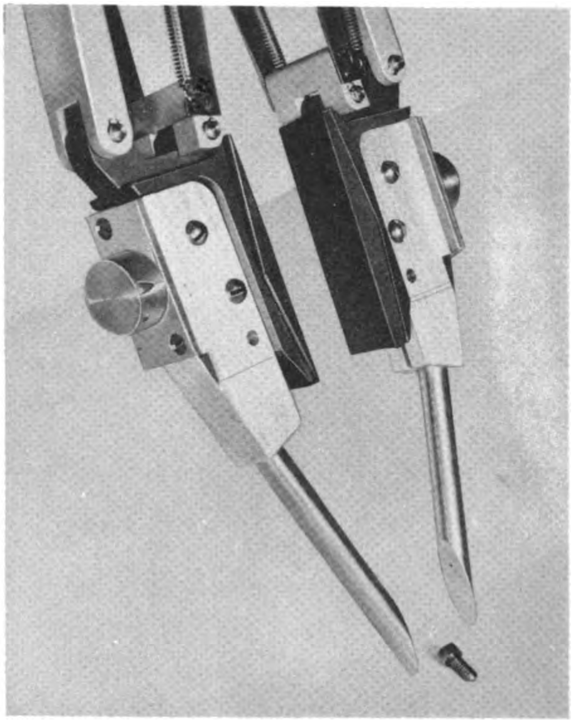


Fig. 2 Manipulator jaws with fingers assembled.

APPLICATION

The remote handling of small parts with a master-slave manipulator is greatly facilitated by the use of plug-in fingers.

DESCRIPTION

These fingers fit into light duralumin fixtures (Fig. 1) bolted onto the jaws of Argonne-type master-slave manipulator tongs. Securing the fingers is effected by a small permanent magnet incorporated within the socket of each finger. For weight saving, the fingers themselves are made of Duralumin except for a tip on the inner end where the finger contacts the permanent magnet. With the finger installed, the length of the tong is extended about 2 in.

Although Fig. 2 shows only plain-ended fingers, the ends can be made in a variety of shapes to accommodate whatever shape of part is to be handled.

OPERATION

Use of the plug-in finger is the same as the standard tongs except that their size makes it possible to handle small parts easily. In addition, special fingers can be plugged in for handling special parts.

A special tool can be devised for removing and plugging in fingers, but a second manipulator is more convenient. The beveled upper ends of fingers ensure proper orientation in the tong fixtures while permanent magnets hold them securely in place. Extra fingers are conveniently stored in a rack inside the cell.

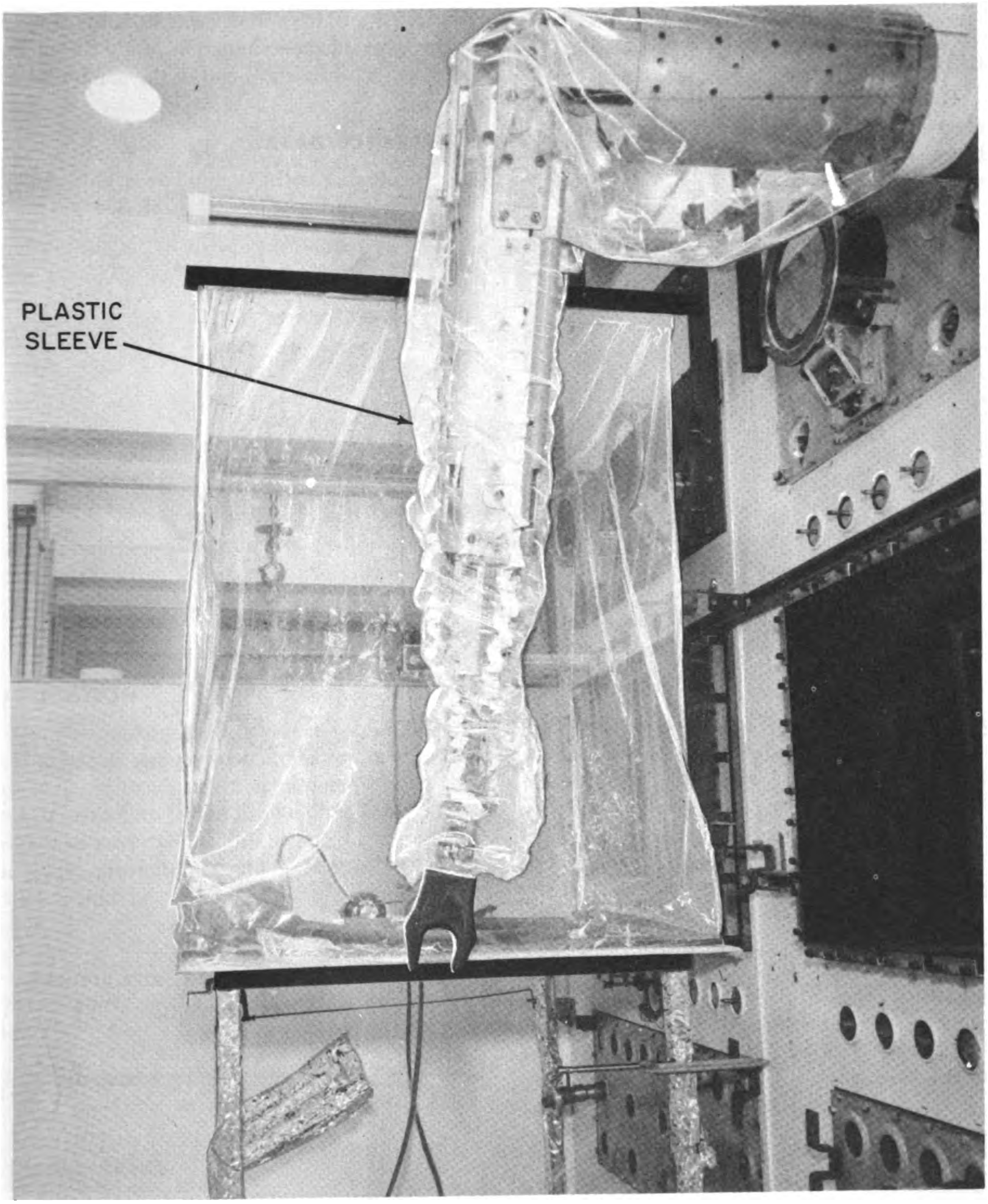
The low cost of the fingers constitutes a considerable advantage since they can be removed and economically discarded when contaminated.

The tong fixtures create very little interference in the normal operation of the tongs with the fingers removed or in place.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: RML-SK-285.

EXPENDABLE PLASTIC SLEEVE



Master-slave manipulator protected by plastic sleeve.

APPLICATION

The expendable plastic sleeve is used to prevent contamination of master-slave manipulators during operation.

DESCRIPTION

The sleeve is made of 0.004-in.-thick vinyl chloride acetate film. It has four ¼-in. elastic tapes attached to its lower end to pull the sleeve up as the slave is raised.

OPERATION

The sleeve and a rubber glove are put on a manipulator before a hot experiment is performed. If gross contamination is liberated during the experiment, the sleeve and glove can be stripped off in a few seconds and discarded. This prevents contamination inside the mechanical parts of the slave end of the manipulator.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: RML-SK-394.

MANIPULATOR BALL COVER AND GAUNTLET

Fig. 1 Manipulator ball cover and gauntlet with cover sleeve.

APPLICATION

The manipulator ball cover and gauntlet are used as an air seal and contamination barrier between a ball-and-socket manipulator and the containment box inside a shielding wall. This protective cover allows full use of the manipulator while preventing contamination of the ball which could be transmitted into an operating area.

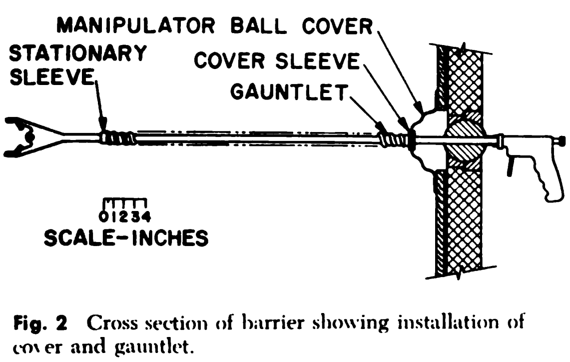


Fig. 2 Cross section of barrier showing installation of cover and gauntlet.

DESCRIPTION

The manipulator ball cover is designed to cover a 5-in.-diameter ball. The gauntlet is molded into a bellows form to permit linear flexibility. The two plastic parts are made of Tygon. The metal sleeves are made of brass and coated with enamel. The sleeves are made in two sizes, for $\frac{3}{8}$- and $\frac{5}{8}$-in.-diameter tongs.

OPERATION

The manipulator cover is attached to the port of the containment box with tape or an appropriate metal bracket. The gauntlet attaches to the cover sleeve and to a stationary sleeve just behind the head of the manipulator.

REFERENCE DATA

Location: Savannah River Laboratory.

ADJUSTABLE FOCUSING TABLE

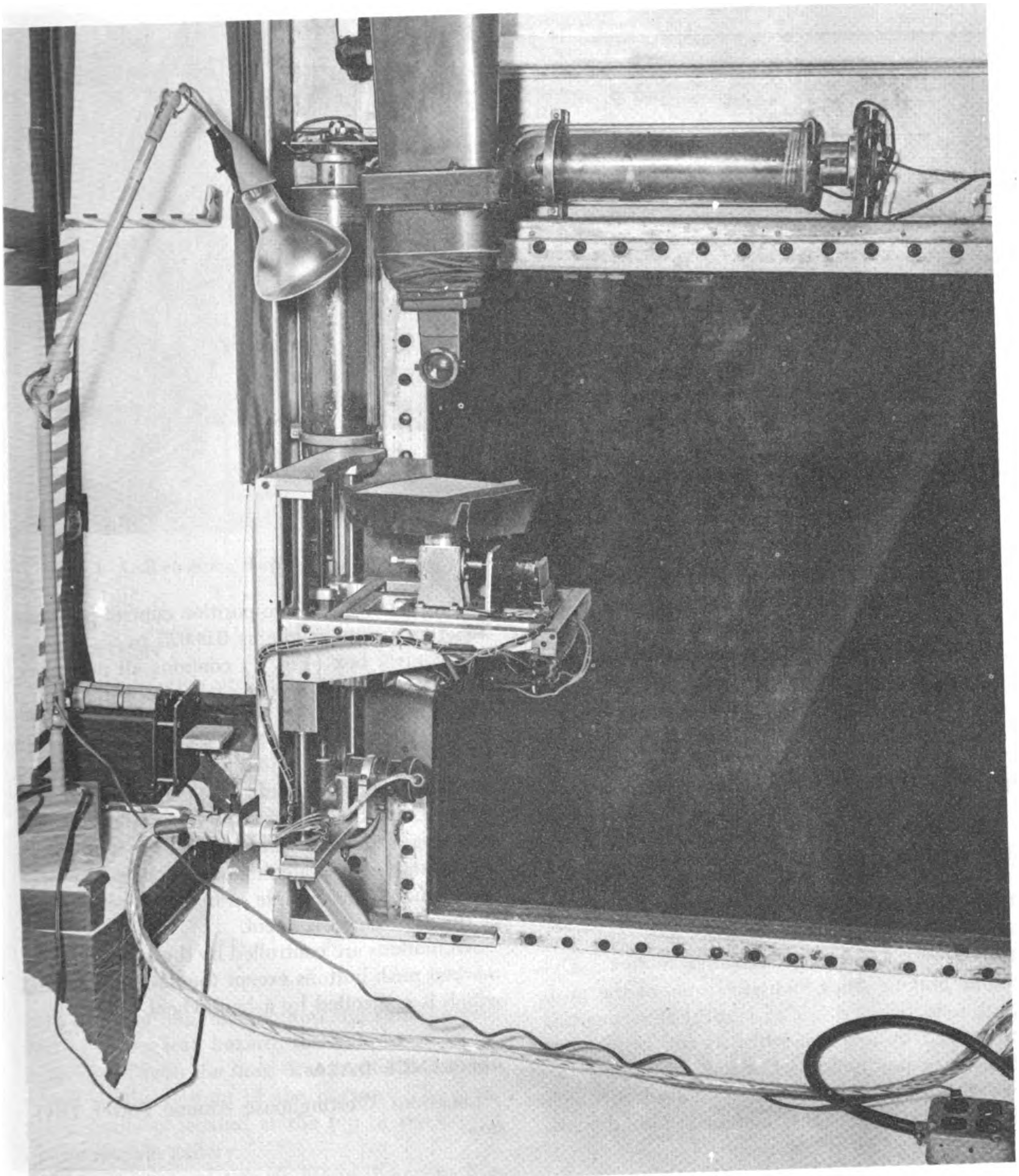


Fig. 1 Adjustable focusing table inside cell.

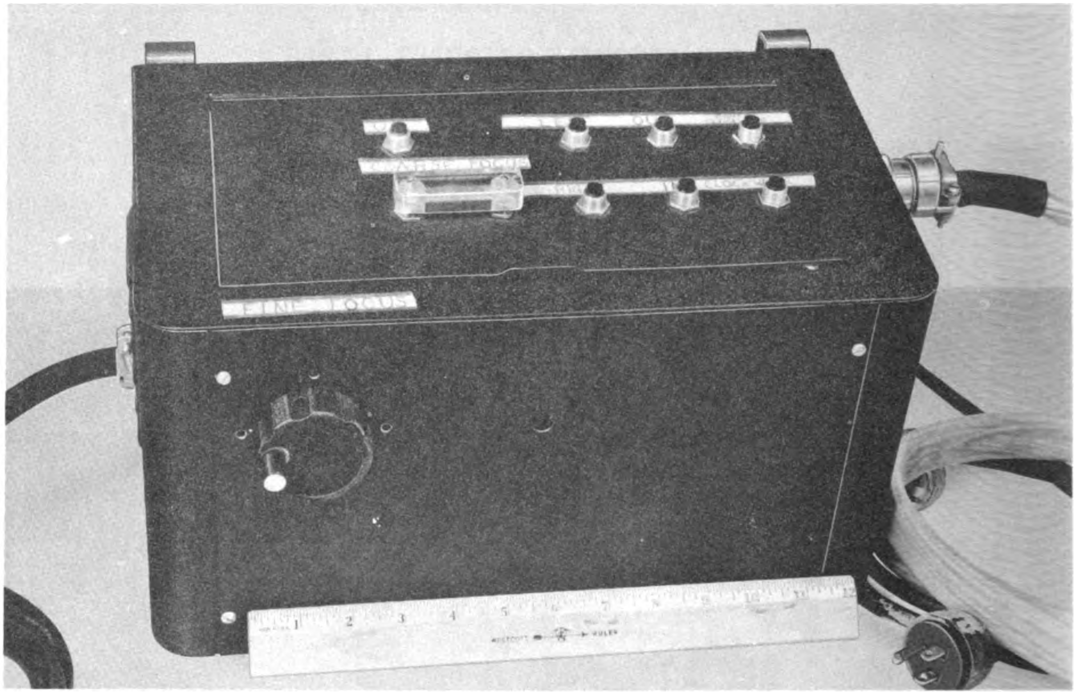


Fig. 2 Control box.

APPLICATION

A means of remotely positioning an object in a hot cell so that it may be examined with any high-magnification optical instrument is provided by an adjustable focusing table.

DESCRIPTION

The primary feature of the apparatus is that the specimen may be quickly positioned by power. The motions are vertical, longitudinal, transverse, and rotary about a vertical axis. All movements, except the vertical one, are controlled by push-button-activated motors. Dynamic braking stops motion as soon as the push button is released. The vertical movement is controlled by a selsyn which is run as a motor for coarse positioning. For fine positioning the selsyn is driven by another external selsyn which is hand-operated. This motion is also dynamically braked. The five-position control provides for adjustments as fine as 0.00025 in.

A control box (Fig. 2) contains all necessary controls, including a power switch.

OPERATION

The control box should be mounted in such a position that the table can be seen by the operator through the cell window. This location permits faster coarse alignment and helps to prevent running the sample into the objective lens of the viewing instrument.

All motions are controlled by the appropriately marked push buttons except the fine adjustment, which is controlled by a handwheel.

REFERENCE DATA

Location: Westinghouse Atomic Power Division.

AIR-LIFT SAMPLER

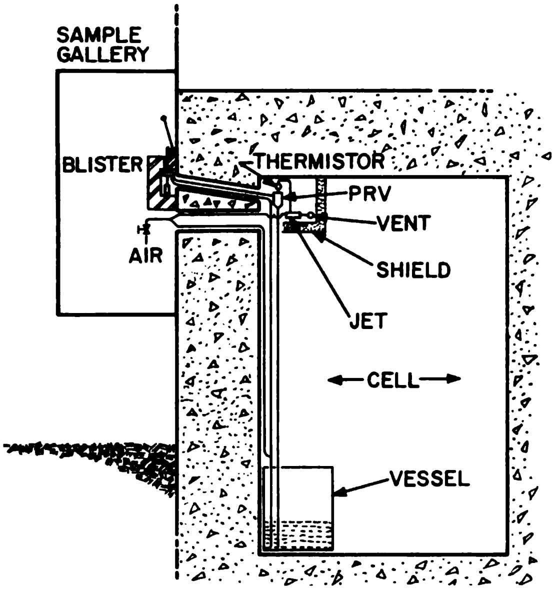


Fig. 1 Cell elevation showing sampler piping.

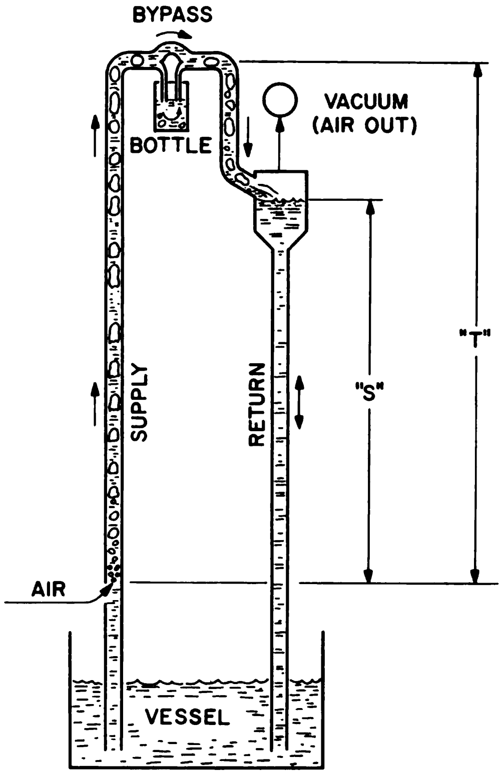


Fig. 2 Diagram of sampler loop.

APPLICATION

The recirculating air-lift sampler is used in a remote-liquid-sampling process to obtain samples from tanks and pipes of a radiochemical pilot plant. A recirculating sampler system is used because large volumes of solution are required to rinse the pipe through which the sample is drawn and the pipe-to-bottle connections. The specific gravity of the samples varies from 0.8 to 1.6.

DESCRIPTION

In order to minimize holdup and rinse volume and to lessen leak hazard, the sampler (Fig. 1) is arranged with the lines draining back into the vessel at the bottom of the circuit. The sampling bottle is located at the top of the circuit in the sample gallery.

The principle of the air lift is shown in Fig. 2. If a U tube is filled to the level shown and air is bubbled into one leg, the density of the

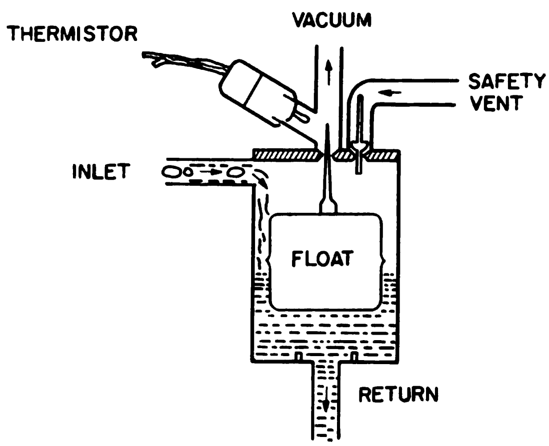


Fig. 3 Pressure regulator valve.

air fluid mixture in that leg is decreased and the liquid rises. In order for the liquid to be lifted to the top (distance T), it has to be held at least halfway (submergence S) to the top by means of the vacuum. S must be less than T to prevent liquid entering the vacuum source.

This is accomplished by means of a float-operated pressure-regulator valve (Fig. 3). If the liquid level rises, the float drives a cone into an orifice and increases the back pressure, causing the liquid level to drop. If the proportion of lift air to vacuum decreases, the float raises the safety-vent stem, letting in air and increasing the back pressure at the cone and orifice. A thermistor shuts off the sampler if the float fails, preventing liquid from reaching the vacuum source.

OPERATION

The sample is collected by forcing a rubber-capped bottle onto a pair of hypodermic needles which form part of the recirculating loop.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Document: H. G. Duggan and J. W. Landry, Remote Liquid Sampling Report: A Completely Automatic Air-lift System, *Nucleonics*, vol. 12, no. 11, 1954.

REMOTE PIPETTE AND ELEVATOR

APPLICATION

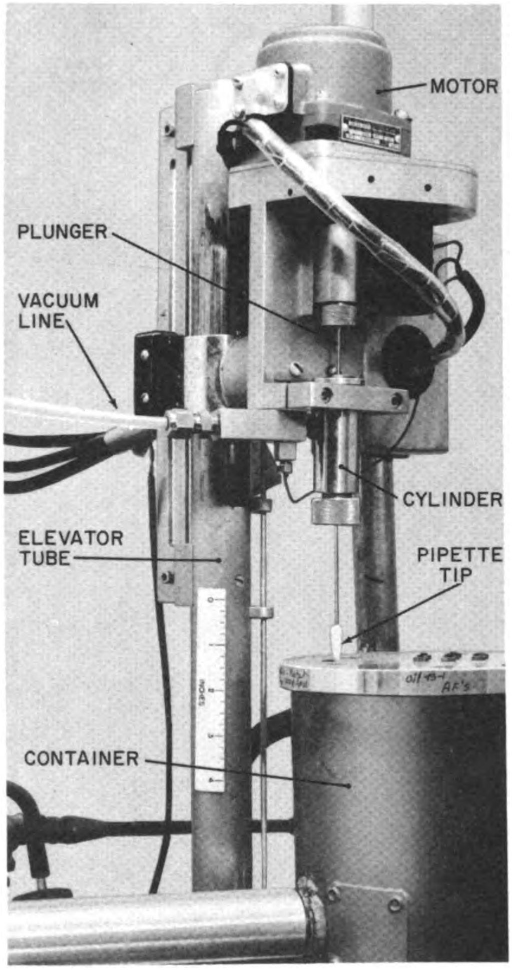
The remote pipette and elevator are used for the dilution of radioactive samples and for specific-gravity determination by the falling-drop method.

DESCRIPTION

The remote pipette has a cylinder in which a plunger operates through a Teflon packing. The plunger is attached to a traveling nut which runs on a motor-operated screw. The motor is a balancing type and is geared to a helical potentiometer which indicates the position of the plunger. A platinum probe is located in the fluid circuit to indicate when the cylinder is filled. All parts which come into contact with the solution are made of stainless steel or Teflon. The pipette is available in 1 and 0.1 ml capacities. The pipette elevator utilizes a motorized screw to cause movement of a cylindrical block riding inside a tube. The tube is slotted along one side to permit attachment of the pipette. The position of the elevator is controlled by adjustable limit switches.

OPERATION

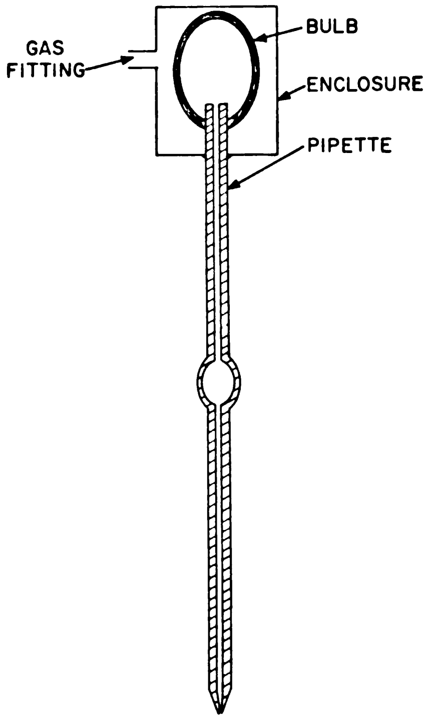
With the pipette tip submerged, the plunger is raised to the upper limit of its stroke. This uncovers an opening in the side of the cylinder. This opening is connected to a vacuum line. The vacuum draws the liquid into the cylinder. When the liquid reaches the platinum probe, the vacuum supply is shut off. The accurately measured amount of liquid may then be delivered to another container for dilution or used for specific-gravity measurement.



REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawings: E-19550, D-21064, D-21065.

PIPETTE CONTROL



APPLICATION

This pipette control was designed and used for sampling radioactive solutions remotely by means of a manipulator. It is suitable for other similar sampling operations.

DESCRIPTION

A standard pipette is fitted with a flexible bulb enclosed in an airtight enclosure. This enclosure is fitted with a connection so that air, or other gas, can be introduced at such a pressure that the bulb will collapse. Immersing the tip in the solution to be sampled and removing air pressure cause the pipette to fill. Discharge is effected by introducing air at the fitting. The device may be moved about by a manipulator. The enclosure and the bulb can be made of any suitable materials.

REFERENCE DATA

Location: Mound Laboratory.

INTERVAL SAMPLER

APPLICATION

This interval sampler is useful for automatically collecting liquid samples in sequence so that the course of a reaction may be followed by analysis of the samples. It is particularly useful for overnight unattended operation.

DESCRIPTION

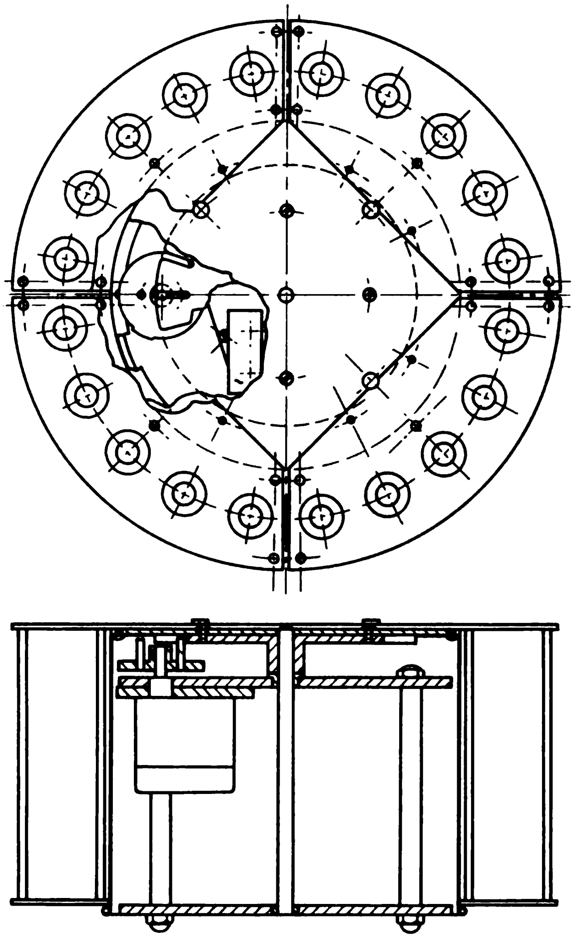
The interval sampler has a turntable 12 in. in diameter with holes around its periphery to hold 20 test tubes. A 24-rpm motor rotates a cam plate, through opposite sides of which extend two pins. These pins alternately engage slots in a Geneva plate, advancing this plate and the turntable which is fastened to the plate as the motor rotates. A microswitch, actuated by the cam plate, and an on-off timer (not shown) act as a three-way switching circuit to control movement of the turntable. The length of time each test tube is in the filling position is determined by the timer setting. At the end of this time, the motor is turned on and advances the next tube into the filling position. For corrosion resistance, most parts are of stainless steel.

OPERATION

This apparatus is located to position one of the 20 test tubes directly under a capillary tube or other sampling device from which the solution drips at slow intervals. The timer permits the desired collection interval before rotating the next test tube into the receiving position.

REFERENCE DATA

Location: Mound Laboratory.



Assembly drawing of interval sampler.

Reference Drawings: Assembly 4-1197; Details, 2-1382, 1-2128, 2-1378, 2-1410, 2-1377, 2-1380, 1-2121, 1-2130, 2-1381, 1-2123, 1-2124, 1-2125, 1-2129, 2-1379, 1-2122, 1-2127, 1-2120, 3-1196, 3-1197, 1-2091.

REMOTE LIQUID SAMPLER

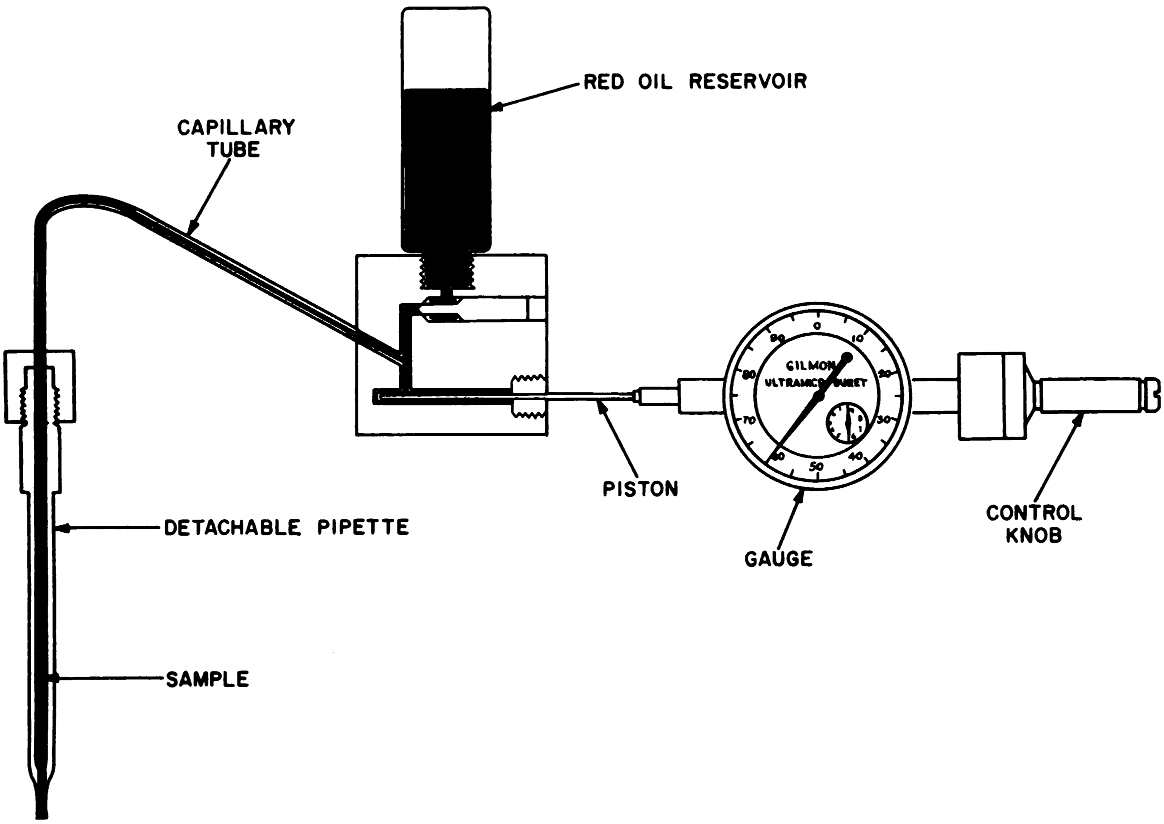


Fig. 1 Schematic of liquid sampler.

APPLICATION

This remote liquid sampler may be used in process or laboratory sampling and may be adapted to through-the-wall sampling.

DESCRIPTION

The remote liquid sampler (Fig. 2) is an adaptation of an ultramicroburette. It consists of a dial micrometer gauge graduated in tenths of a microliter with an extended range dial reading to the 100-microliter capacity of the system. The control knob of the micrometer is geared both to the dial and to the precision-machined plunger of the syringe. The syringe is connected to a removable pipette through a stainless-steel capillary tube to which is attached a fluorothene reservoir for the paraffin-base oil. This mineral oil is dyed red for better visibility since it is the positive displacement medium for drawing and expelling the sample. The pipettes, made of nonwetting Teflon or fluorothene, are threaded for secure attachment to the capillary tube from the syringe. The sampler is incorporated into a mount which provides safe vertical, radial, and horizontal motion over a barrier. A schematic of the sampler is shown in Fig. 1.

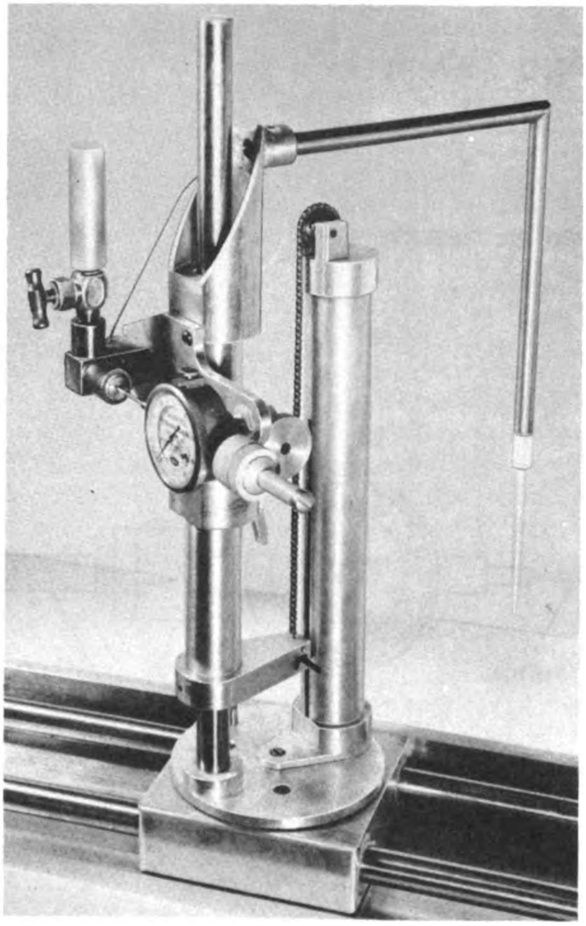


Fig. 2 Remote liquid sampler.

OPERATION

Since the plunger is machined to displace exactly 100 microliters in its full travel, no calibration is required. After the pipette has been attached and the micrometer dial set at 1000 (on the dial this is the same as 0, but it indicates that the piston is fully extended), oil is introduced into the pipette by opening the reservoir valve. When the pipette is full, the valve is closed and the pipette is wiped. The pipette is next immersed in the sample, part of which is then drawn into the pipette with a counterclockwise rotation of the control knob of the micrometer. The filling and expelling of the liquid in the pipette are controlled by the dial position instead of aligning the liquid interface at a calibration mark. The exterior of the pipette is rinsed before the sample is expelled. After use the pipette is readily decontaminated in laboratory cleaning solution, and the oil which contacted the sample is expelled to waste.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Drawings: H-4-2373 to H-4-2377.

Reference Document: K. H. Hammill, The Hanford Remote Pipetter, HW-30556, Jan. 15, 1954.

PUNCTURE MECHANISM FOR GAS SAMPLING

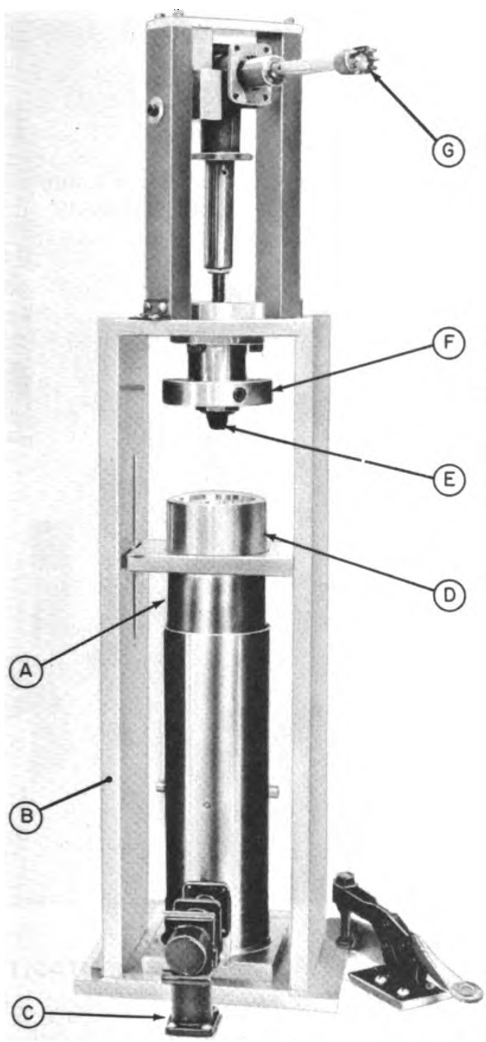


Fig. 1 Puncture mechanism.

APPLICATION

The puncture mechanism is used to sample the gases from small irradiation capsules. It accommodates cylindrical samples up to 4 in. in diameter and 4 in. long. A vacuum seal is made on a flat surface, and the device is capable of puncturing through a stainless-steel diaphragm 0.010 in. thick. It is remotely operated from outside a shielded cell.

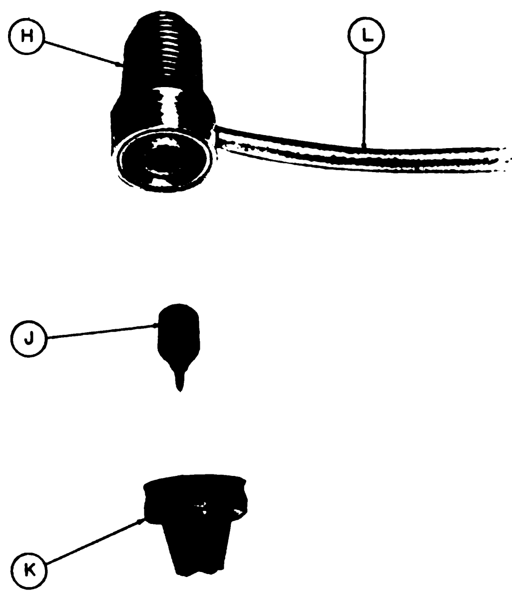


Fig. 2 Bellows assembly.

DESCRIPTION

The puncture mechanism (Fig. 1) consists of a frame assembly, lower piston assembly, and puncture pin and seal assembly. The lower piston (*A*) is mounted on the frame (*B*) and is screw driven vertically by the angle gear and drive linkage (*C*). Located at the top of the piston is a centering plate (*D*) which is grooved to center the capsule assembly on the mechanism.

The molded rubber seal (*E*) is mounted below the bellows assembly (*F*). The bellows assembly is compressed by the upper drive mechanism (*G*).

The bellows assembly (Fig. 2) consists of a bellows (H), which contains an internal magnet, the puncture-needle magnet assembly (J), and the rubber seal (K). The magnets are used to facilitate convenient removal of the puncture pin in case of breakage. The gas sample is collected through the tubing connection (L).

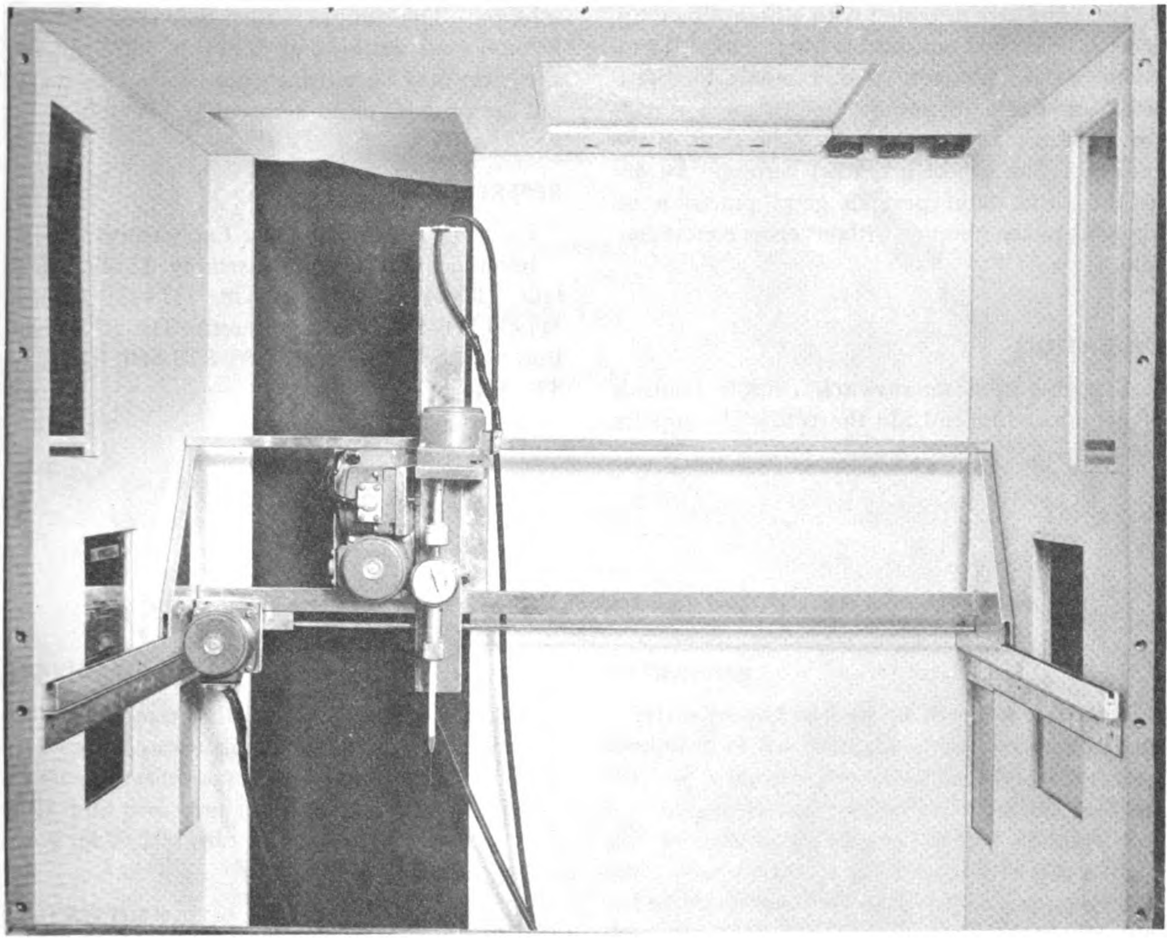
OPERATION

The lower piston is set at the lowest position, and the sample is placed on the piston plate. The piston is driven upward until the sample butts against the rubber seal and a vacuum-tight seal is made. The upper drive is actuated and the bellows is compressed, which in turn drives the puncture pin down to puncture the capsule. After the puncture occurs, the released gases are collected for analysis. The lower piston is lowered, and the sample is removed.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: KAPL T-7A8540.

JUNIOR-CAVE CRANE PIPETTER



APPLICATION

This pipetter is designed to facilitate remote sampling of hot solutions inside a hot cell. A modified electrically driven microburette, which serves as the sampling device, is mounted on a miniature bridge crane that provides three independent degrees of freedom. All motions are electrically powered and controlled from a console outside the cell. Samples up to 0.2 ml may be taken. Samples of 0.020-ml size are delivered with a precision of 1 per cent.

The fluorothene tip on the burette reduces cross contamination to a minimum on aqueous samples because of its nonwetting characteristics.

The pipetter may also be used to move equipment around inside the cell by means of a special pickup hook.

DESCRIPTION

The pipetter, constructed primarily of aluminum, is designed to fit inside a 36-in.-wide isolation box. The 110-volt a-c motors used are capable of being stalled indefinitely. All motions are powered through rack-and-pinion

drives. Microswitch controls permit accurate positioning and pipetting. Limits on the travel in each degree of freedom are:

X motion—29 in.
Y motion—16 in.
Z motion—20 in.

The burette is provided with a fluorothene tip, instead of a glass one, and is fitted with a 0.2-ml stainless-steel plunger. Other minor modifications are made to permit the use of a direct-drive electric motor attached to the shaft of the burette. The use of a refined kerosene solvent as the drive fluid permits good precision on aqueous-phase samples without cross contamination.

OPERATION

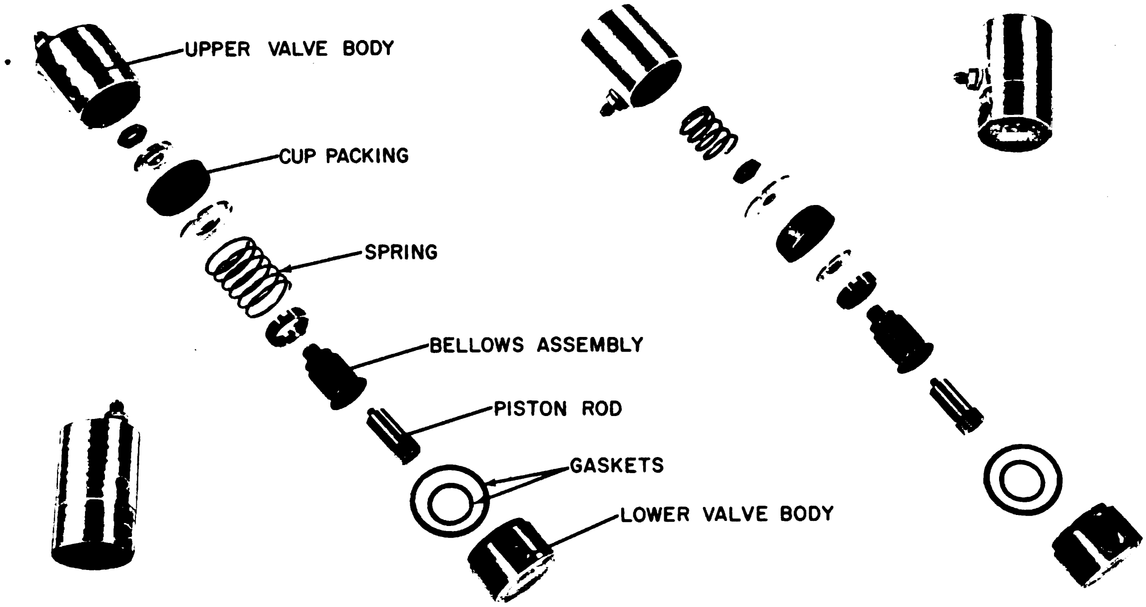
A push-button microswitch console controls all motions from outside the cell. The pipette is positioned over the container to be sampled and lowered until the fluorothene tip is submerged in the liquid. The sample is taken by manipulating the proper controls on the console. The burette tip is then cleaned by expelling a small amount of sample in a dummy solution. The sample is then delivered and the volume read on the dial indicator. The fluorothene tip may be satisfactorily cleaned by flushing the tip with clean kerosene solvent.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawings: Assembly 114175; Details 117424, 117432, 117436, 117443, 117444, 117459, 117460, 129231; Burette Tip ST3-1509; Burette Modification ST3-868, ST3-869, ST3-870, ST3-871.

AIR-OPERATED BELLOWS VALVE



A ⅛-in. normally open valve is shown on the left and a ¼-in. normally closed valve on the right.

APPLICATION

This compact valve is designed for installation in chemical-processing equipment for the remote pneumatic control of fluid or air flow in lines with fluid pressures up to 50 psi, using air pressures up to 100 psi.

DESCRIPTION

The bellows valve may be used for either normally open or normally closed service, depending on the assembly order of its parts. Except for the spring and lower valve body, all other parts (upper body, cup packing, steel bellows, piston rod, and sealing gaskets) are interchangeable for either application. Lower valve bodies are available with ⅛-, ¼-, or ⅜-in. port sizes. All parts in contact with the liquid are of stainless steel or Teflon.

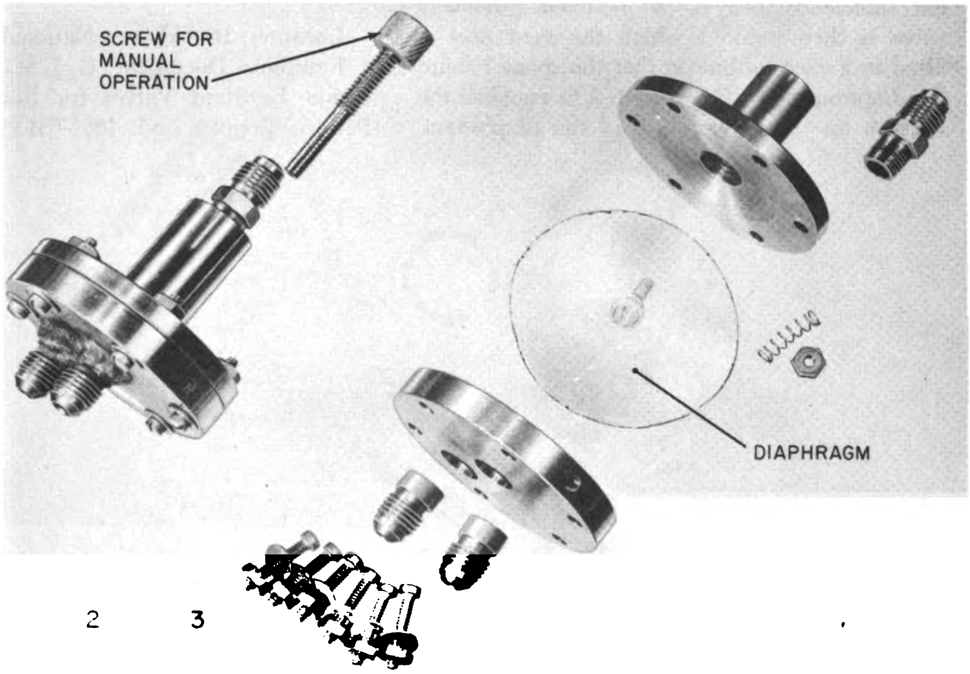
OPERATION

When compressed air at 50 psi is admitted at the fitting of the normally closed valve, the cup packing is forced away from the port, withdrawing the piston rod within the extended bellows and permitting the liquid to flow through the port. For normally open operation, air admitted at the fitting forces the cup packing toward the port, seats the piston rod, and blocks the port. In both types of operation, normal position is resumed by the action of a return spring when air pressure is removed.

REFERENCE DATA

Location: Brookhaven National Laboratory.

DIAPHRAGM VALVE



0 1 2 3

Valve assembly and detail parts.

APPLICATION

This small pneumatically operated valve, known as the Selvin diaphragm valve, is for use on nonflexible tubing, such as Saran or stainless steel, with outer diameters of 1/8 to 3/8 in. A screw may be inserted into the air fitting to permit manual operation of the valve. The valve was designed specifically for use in the remote processing of highly radioactive materials.

DESCRIPTION

The valve body is made of two stainless-steel disks, bolted together at their periphery. One of the disks has the inlet and outlet ports; the other has a single port for the control of air. The inner faces of the disks are slightly concave to permit movement of a Kel-f diaphragm which is clamped between the two halves of the body. The diaphragm is molded with a conical tip in the center of one side and a metal screw in the center of the opposite side. The conical tip seats in the inlet port in the valve body, sealing it when pressure is applied to the opposite side of the diaphragm. The metal screw is fastened to a return spring which opens the valve when the air is vented. The maximum fluid holdup is 2 ml. The hand screw which is used for manual operation must be removed if pneumatic control is desired. The materials used were selected to withstand decontamination procedures.

OPERATION

Air pressure applied to the diaphragm causes the conical tip at the center of the diaphragm to seat against the fluid inlet port. Removal of the air pressure permits the return spring to pull the diaphragm back to the open position. Intermediate pressures may be used to regulate the fluid flow. An actuating air pressure of 55 psi is sufficient to close the valve completely against

25 psi gas or fluid pressures. Other ratios could be used.

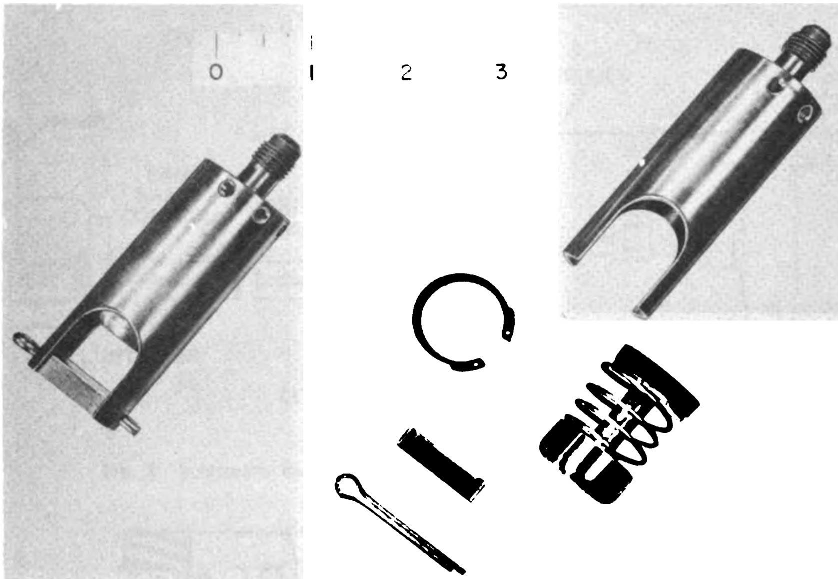
For service in which the diaphragm valve is to close off a vacuum line, the return spring is not sufficiently heavy. A modified three-way valve is then used in which the vent port is fitted to a vacuum line so that the space behind the diaphragm can be evacuated to equalize the vacuum on the system side of the diaphragm. In this manner the return spring will operate satisfactorily.

REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: G. J. Selvin, Small Corrosion Resistant Valves for Remote Chemical Service, Report: BNL 186(T31).

SQUEEZE VALVE



Valve assembly and detail parts.

APPLICATION

The squeeze valve is designed for installation on flexible plastic or rubber tubes processing highly radioactive material. It is remotely controlled and pneumatically operated. The valve accommodates $\frac{1}{4}$- to $\frac{3}{8}$-in.-ID tubing and can be readily modified for larger diameters.

DESCRIPTION

The squeeze valve is approximately $3\frac{1}{2}$ by $1\frac{1}{4}$ in. In order to withstand decontamination procedures, all parts but the neoprene cup washer are stainless steel.

OPERATION

Installation of the valve on the tubing is made by inserting the tube through the opening in the valve body or by placing it in position after removal of the cotter pin and bottom block. Air pressure applied through the flared fitting forces the piston and plunger down, squeezing the tubing closed against the bottom block. The valve is opened by the removal of air pressure and the action of the return spring.

REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: G. J. Selvin, Small Corrosion Resistant Valves for Remote Chemical Service, Report: BNL 186(T31).

BELLOWS PUMP

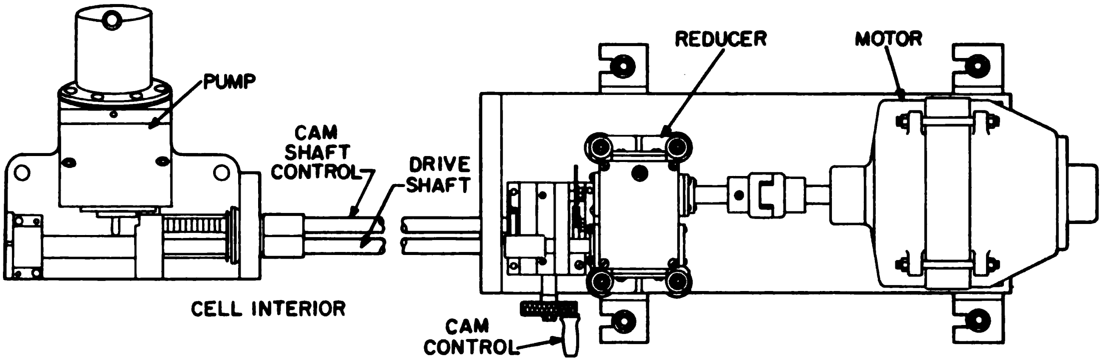


Fig. 1 Schematic diagram of power transmission to pump (top view).

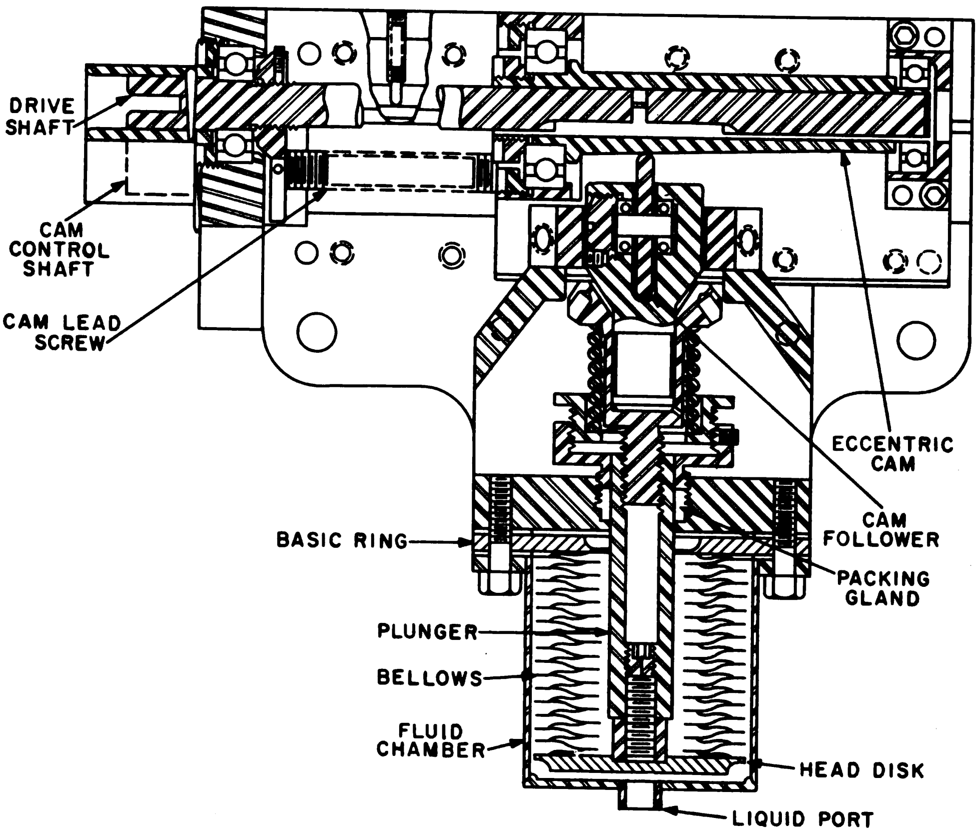


Fig. 2 Bellows pump cross section.

APPLICATION

The bellows pump is designed to deliver active, corrosive 1.5 to 1.95 specific gravity salt solutions against a static discharge head of 30 ft at a controlled flow of 10 to 100 ml/min. Since this is a positive-displacement pump with all motion confined to the bellows, abrasive and very viscous materials can be handled.

DESCRIPTION

The bellows pump is driven at 44 rpm by a shaft through a 40:1 gear reducer coupled to a ¼-hp motor. A cam-control wheel is mounted on the gear reducer, and both drive shaft and cam-control shaft may be of any practical length to enter the cell. A corrugated welded-type bellows, head disk, spring-loaded plunger, and base ring form the pump impeller. The fluid chamber is set at a slight angle for positive drainage through a cleanout port when required. To reduce the possibility of leakage, the fluid chamber has a single port. Check valves for flow control are placed in the pipelines and are not a part of the pump itself. This permits a greater variation of service. A roller-type cam follower, attached to the lower end of the plunger, is in contact with a cylindrical eccentric cam. The cylindrical cam is concentric with the drive shaft. The bellows and fluid chamber are of stainless steel for best acid- and corrosion-resistant operation.

OPERATION

The rotation of the eccentric cam against the cam follower produces an upward movement of the plunger, expanding the bellows and displacing the fluid. Discharge is controlled by the length of stroke, and this length is altered by changing the eccentricity of the cam. Cam eccentricity is changed by sliding the cam along the drive shaft by means of a lead screw which is turned by the cam-control wheel.

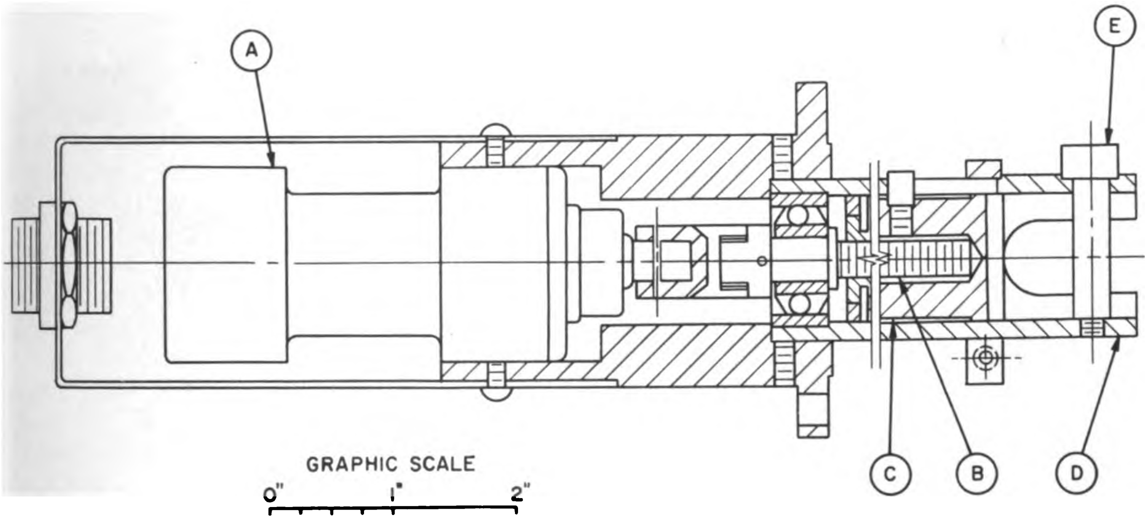
The plunger operates through a packing gland to prevent internal leakage in case the bellows should rupture and become filled with the fluid.

There is no flow-direction control in the pump itself. Check valves are included in the piping of the system to which the bellows pump is applied.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: D-4645.

MOTORIZED PINCH VALVE



APPLICATION

The motorized pinch valve was designed to remotely control the flow of a fluid by pinching off flexible tubing.

DESCRIPTION

The pinch valve shown in the drawing consists of a small d-c motor assembly (*A*), which rotates at 250 rpm and which, by means of a lead screw (*B*), moves a plunger (*C*) along a barrel (*D*). Flexible tubing threaded through the barrel will be pinched between the end of the plunger and a stripper bolt (*E*) which extends across the barrel.

OPERATION

The unit is operated by actuating a reversing switch which will rotate the motor in the desired direction. The lead screw has 80 threads per inch; fine control of the fluid flow through the tubing can be attained.

REFERENCE DATA

Location: Mound Laboratory.

Reference Drawings: Assembly Drawing 3-1190.

Detail Drawings 1-2147, 1-2089, 1-2090, 1-2092, 1-2093, 1-2094, 1-2095, 1-2096, 1-2097, 1-2098, 1-2099.

FLUID-TRANSFER-LINE DISCONNECTS

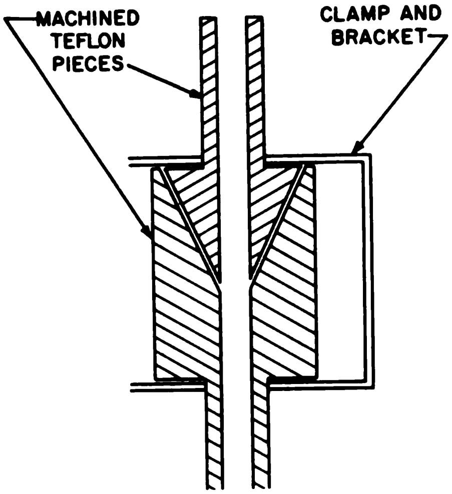


Fig. 1 Cross section—Teflon disconnect.

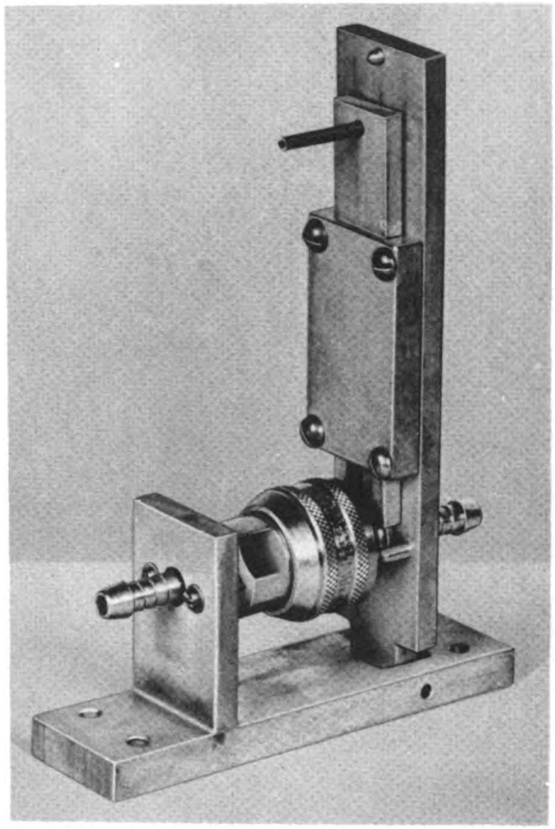


Fig. 2 Standard disconnect.

APPLICATION

These fluid-transfer-line disconnects are used in chemical processing to facilitate connection and disconnection of fluid lines with the aid of a manipulator.

DESCRIPTION

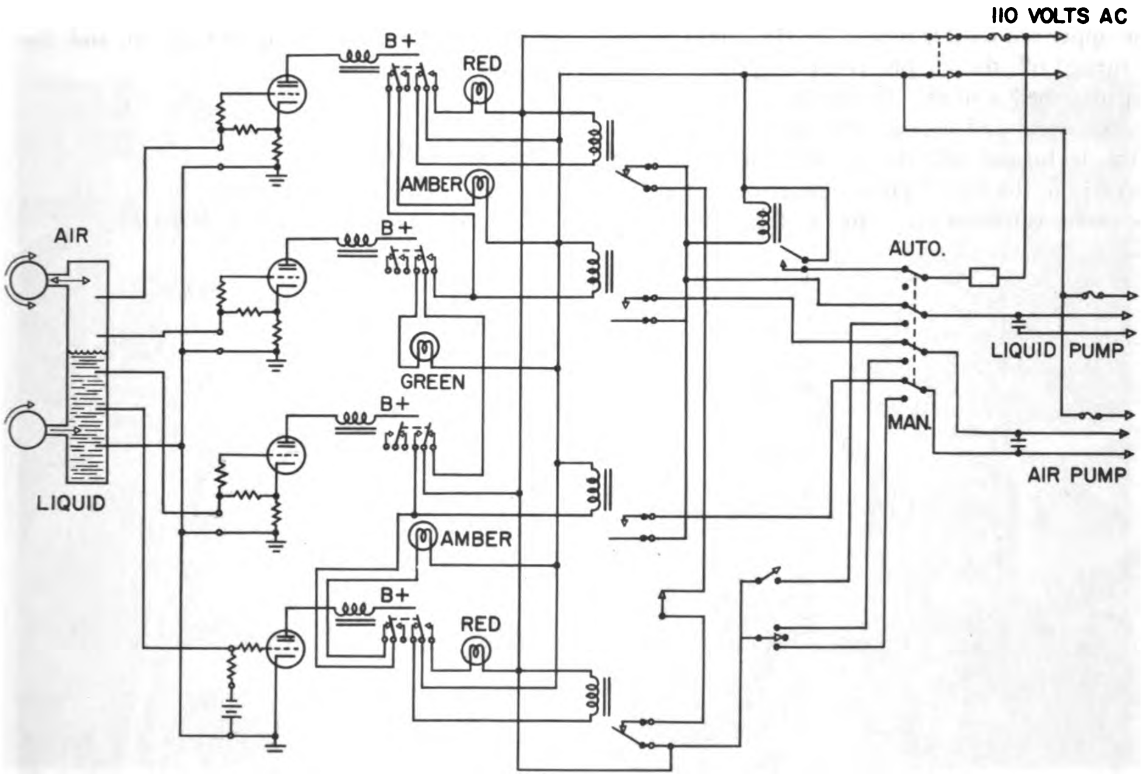
The quick-change Teflon disconnect (Fig. 1) consists of a block with a tapered cavity and a plug machined to fit this cavity. Both pieces are center-bored to allow fluid passage and are machined to accommodate tubes at the outer ends. Both plug and block and held together by a clamp which also serves as a mounting bracket.

The commercially available disconnect (Fig. 2) is fitted with standard-type hose fittings and mounted in a fixture. This fixture serves as a mount and as a mechanical aid in coupling and uncoupling the disconnect by means of a manipulator.

REFERENCE DATA

Location: Mound Laboratory.
Reference Drawings: 5846, I-ER-F-I.

LIQUID-LEVEL CONTROL



Schematic diagram of liquid-level control apparatus.

APPLICATION

This liquid-level control device maintains a constant liquid level in a column such as an ion-exchange column. It is applicable for similar level control problems.

DESCRIPTION

The device, shown functionally in the diagram, consists of a sensing element, or probe, and an electronic-relay circuit, which functions in various ways depending upon the signal it receives from the sensing element. The sensing element consists of five metal electrodes extending through the wall of the column in which the liquid level is to be controlled. The liquid touches each electrode in turn as its level changes. Level is controlled by two pumps: a liquid pump, which pumps the liquid into the column; and an air pump, which increases the pressure in the closed column, reducing the rate of inflow, or, when reversed, decreases the pressure and tends to hold the liquid back. Level can be maintained within ¼ in. in a ¾-in.-diameter column.

OPERATION

Under normal conditions the liquid level is between electrodes 2 and 3. The green light on the control panel is on, the liquid pump is on, and the air pump is off. If the level rises to cover electrode 2, the green light is turned off, the upper amber light is turned on, the liquid pump remains on, and the air pump is turned

on, increasing the air pressure exerted on the liquid. If the level continues to rise and covers electrode 1, the upper amber light is turned off, the upper red light is turned on, the liquid pump is turned off, the air pump remains on, and the warning bell sounds. If the liquid level drops from normal and exposes electrode 3, the green light is turned off, the lower amber light is turned on, the liquid pump remains on, and the air pump is turned on, reducing the air pressure on the liquid. If the level continues to drop and exposes electrode 4, the lower amber light is turned off, the lower red light is turned on, the liquid pump and air pump remain on, and the warning bell sounds.

REFERENCE DATA

Location: Mound Laboratory.
Reference Drawings: 388-4, 388-4-A.

VALVE OPERATORS

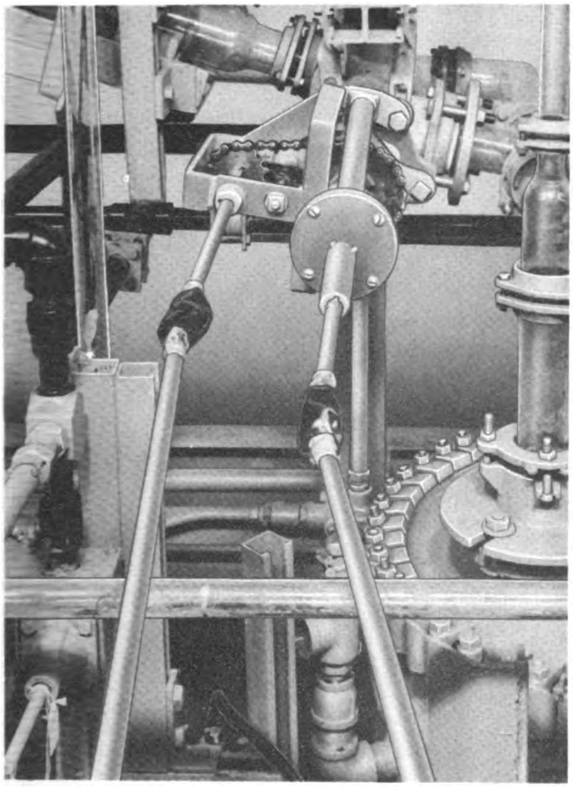


Fig. 1 Rigid-shaft valve operators.

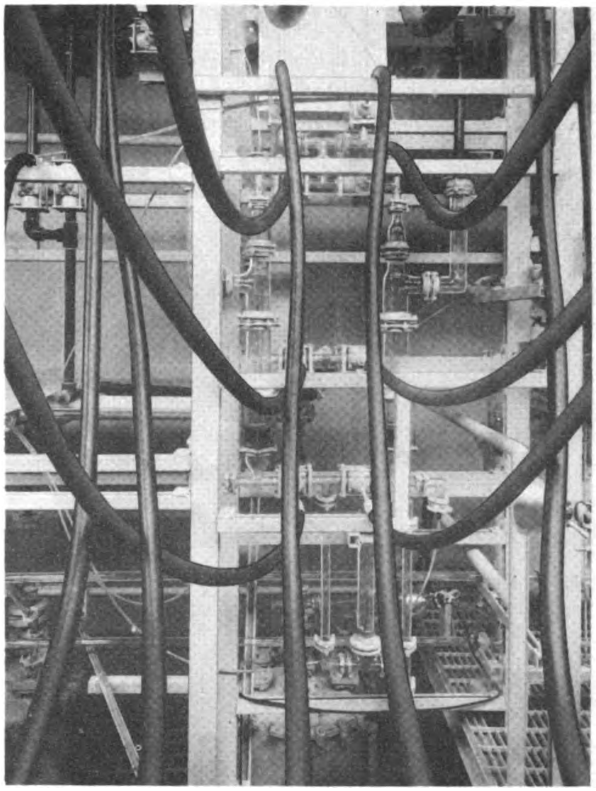


Fig. 2 Flexible-shaft valve controllers.

APPLICATION

These operators are used for opening and closing valves by remote control in areas containing radioactive, corrosive, or toxic materials.

DESCRIPTION

Rotary motion can be transmitted to valves by means of rigid shafts through the use of two universal joints (only one universal joint per shaft is visible in Fig. 1). Valves may be opened or closed through means of a chain-and-sprocket apparatus and the valve plug seated by a push-pull valve operator as illustrated. Shown in the left center of Fig. 1 is a needle valve which is actuated by a rigid-shaft universal-joint combination, while in the lower-left corner is a diaphragm-type valve actuated by this same type of valve operator. The universal joints are lubricated and protected from corrosive atmosphere by packing them well with grease and covering the greased joint with tape.

Long flexible shafts (Fig. 2) are also used in installations not conveniently adaptable to the use of rigid-shaft valve operators; however, the flexible valve operators are not so satisfactory as the rigid type for fine valve control.

An air-operated valve positioner (not shown) consists of a pivoted cylinder containing a spring-loaded plunger, an external plunger extension coupled to a valve handle, and air inlet and outlet ports. The air input control and the air bleed control are remotely operated. Valve movement is a function of the applied air pressure, provid-

ing a means of regulating the amount of opening or closing for both normally open and normally closed valves.

OPERATION

The rigid and flexible extension-shaft valve operators are rotated by hand to open or close valves. The air-operated type functions by admitting air under pressure into the valve cylinder, forcing the plunger outward against the restoring force of the spring. The plunger extension moves the valve handle in the desired direction. Plunger and valve handle are restored to normal position by venting the internal air pressure.

REFERENCE DATA

Location: Mound Laboratory.

Reference Drawings: D-PR-M-85, D-PR-M-86.

PERISTALTIC PUMP ANL MODEL 2

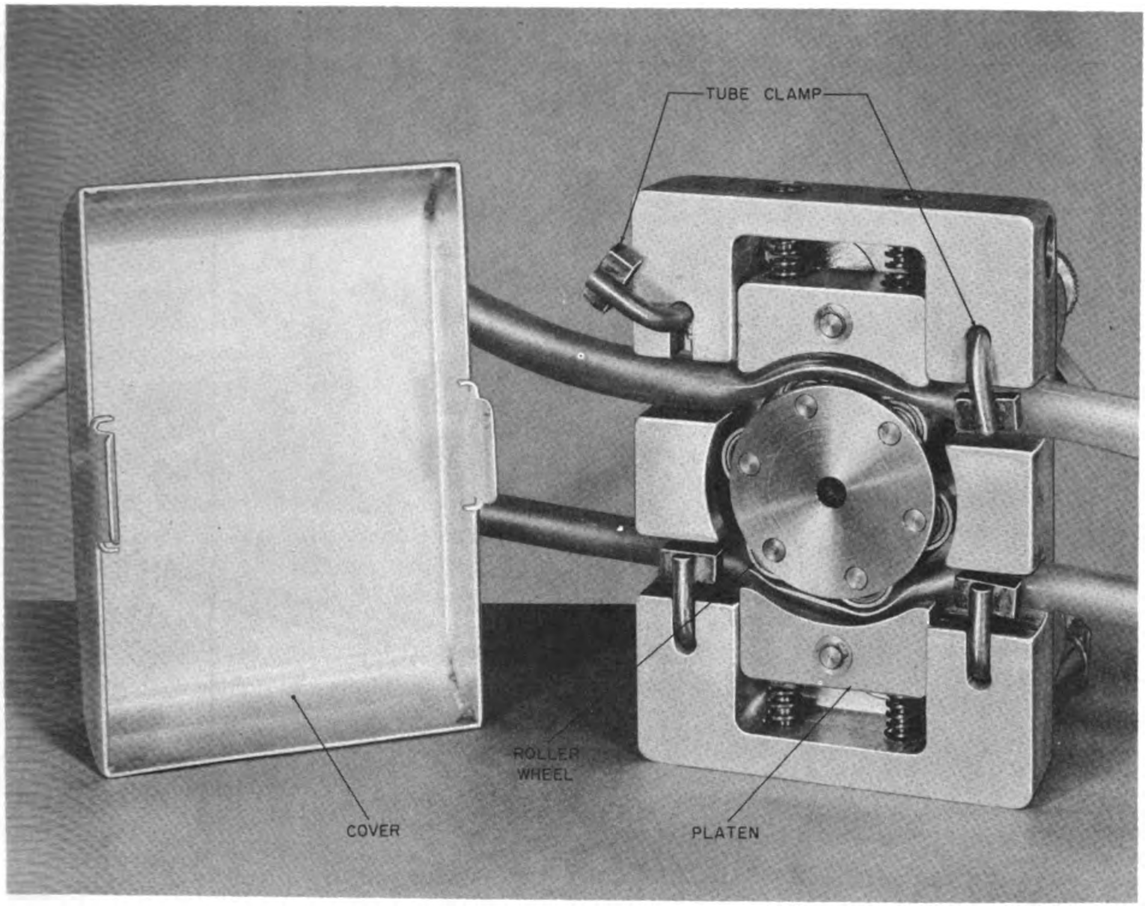


Fig. 1 Pump with cover removed.

APPLICATION

This small pump fulfills the need for a device to move fluids through unbroken rubber or plastic tubes. The tubes can be inserted into the pump without being disconnected from other equipment. It is particularly useful for moving contaminated liquids in closed systems.

DESCRIPTION

The over-all size of the pump is 3½ by 4¾ by 6 in. It will accommodate one or two tubes of ¼ to ½ in. OD, each capable of carrying a different fluid. The pump is powered by a 27-volt d-c motor whose speed may be varied or reversed to change the rate or direction of flow.

OPERATION

Pumping action results from the rolling contact between one or more of six rollers and the tube. The tube is backed up by a spring-loaded platen to ensure that the tube is closed tightly by the rolling contact. Clamps at either side of the housing hold the tubes in position. For tube insertion the clamps may be rotated (Fig. 1) and the platen raised by a lever at the rear of the pump (Fig. 2). Four sockets are avail-

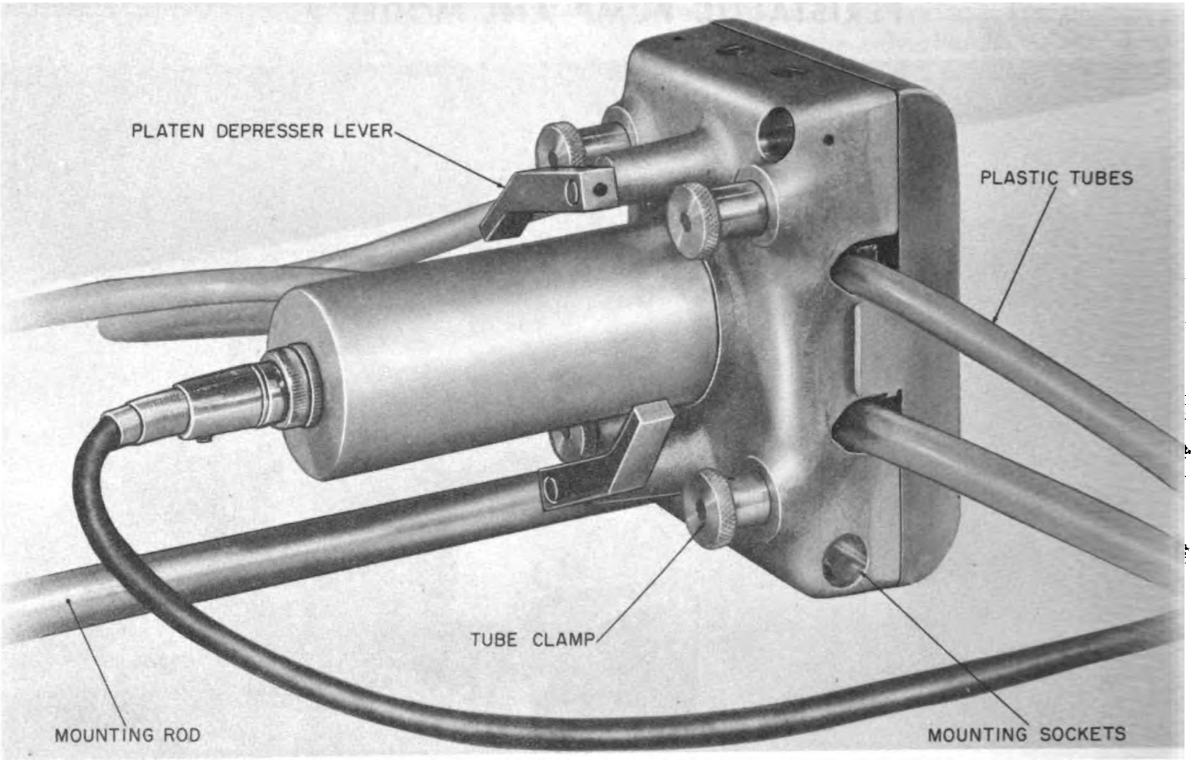


Fig. 2 Pump assembled for operation.

able so that a ½-in.-diameter rod may be used for mounting the pump to a vacuum frame or other hood structure. The working mechanism of the pump is protected by a snap-on cover.

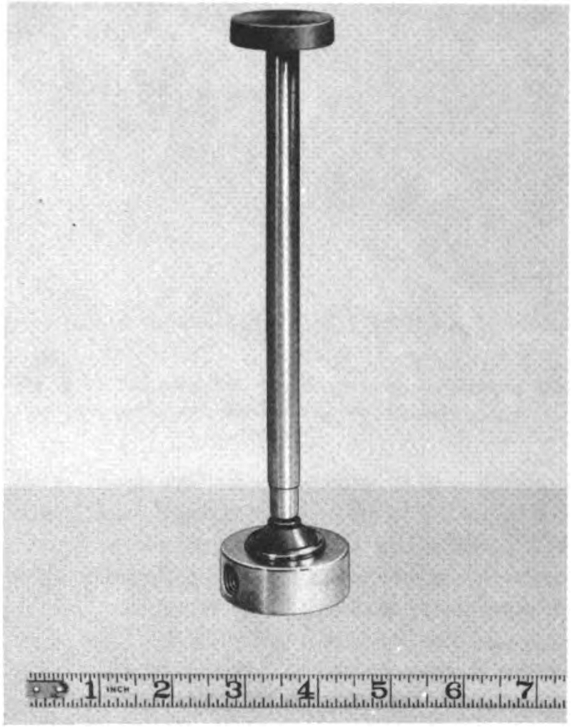
REFERENCE DATA

Location: Argonne National Laboratory.
Reference Drawing: RCD-345.

MODIFIED DIAPHRAGM VALVE

APPLICATION

This modified diaphragm valve has been developed to control fluid flow in radiation fields where plastic seats and packing will fail. All liquid contact is with stainless steel. When the valve is properly mounted, it has almost no holdup. It comes with an 8-in. extension on the handle, but a longer extension could be used. The valve is also available in a three-way model.



DESCRIPTION

The unit consists of a 2-in. cylindrical body with a ¼-in. fluid-port-tube inlet and outlet. The stainless-steel diaphragm is press-fitted into the cavity of the valve. The diaphragm is actuated by a screw which is turned by an 8-in. extension handle. The valve chamber is specially drilled to reduce holdup to a minimum.

REFERENCE DATA

Location: Savannah River Laboratory.

UNIVERSAL REACTION VESSEL, IMPROVED, HEAVY DUTY

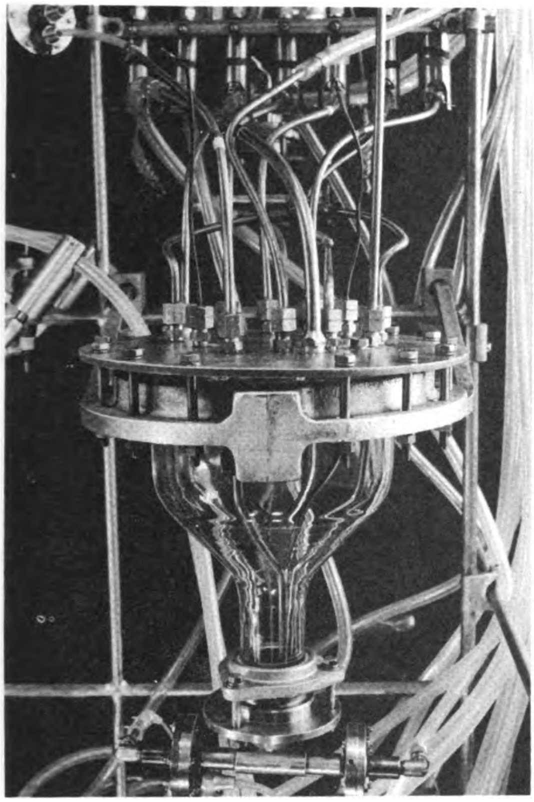


Fig. 1 Reaction vessel mounted on equipment rack.

APPLICATION

This durable vessel, commonly called a Stang reactor, is used for the precipitation, agitation, and filtering of solutions. In operation it has withstood 20 psi without leaking and a water quench from 212 to 50°F.

DESCRIPTION

The vessel (Fig. 1) consists of a glass body, a filter assembly at the bottom, and a head assembly. The original prototype was hand-blown from thin-walled flasks. In the improved heavy-duty model the body is made frcm commercially available Pyrex pipe of the "double-tough" variety. Each end assembly consists of a standard flange, an asbestos insert, and a Teflon gasket bolted to the head and filter assemblies. The head assembly consists of male tubing connectors ($\frac{1}{8}$-in. pipe to $\frac{1}{4}$-in. tube and $\frac{1}{4}$-in. pipe to $\frac{3}{8}$-in. tube) threaded into a $\frac{1}{4}$-in. stainless-steel plate. Short lengths of stainless-steel tubing attached to the connectors serve as nozzles. Fluorothene grease is used to reduce galling and effect a tight seal between the connectors and the headplate.

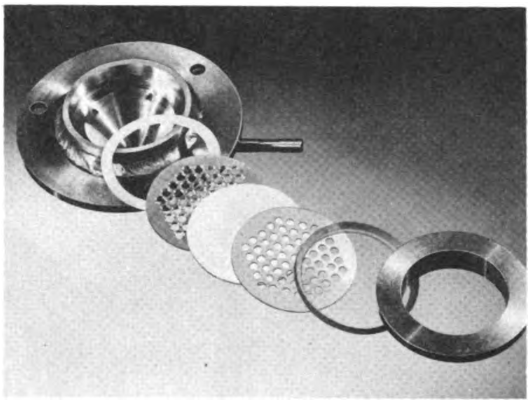


Fig. 2 Filter-assembly details showing fluorothene frit (center), perforated steel plates, and gaskets.

The durable filter (Fig. 2) is made of a fluorothene or Teflon frit and is supported on both sides by a thin perforated steel plate. Chamfered holes drilled through the plate provide maximum filtering area. The supported frit is sealed to the body of the filter assembly by a flat fluorothene gasket and a fluorothene ring of triangular cross section. The metal gland expands the ring gasket against the side wall of the body and compresses it against the top support plate.

OPERATION

Solutions can be maintained in the vessel with or without agitation by applying pressure below the filter disk. The degree of agitation is controlled by the volume of air forced through the disk. Precipitates are filtered by applying air

pressure above the disk, vacuum below the disk, or both together as required.

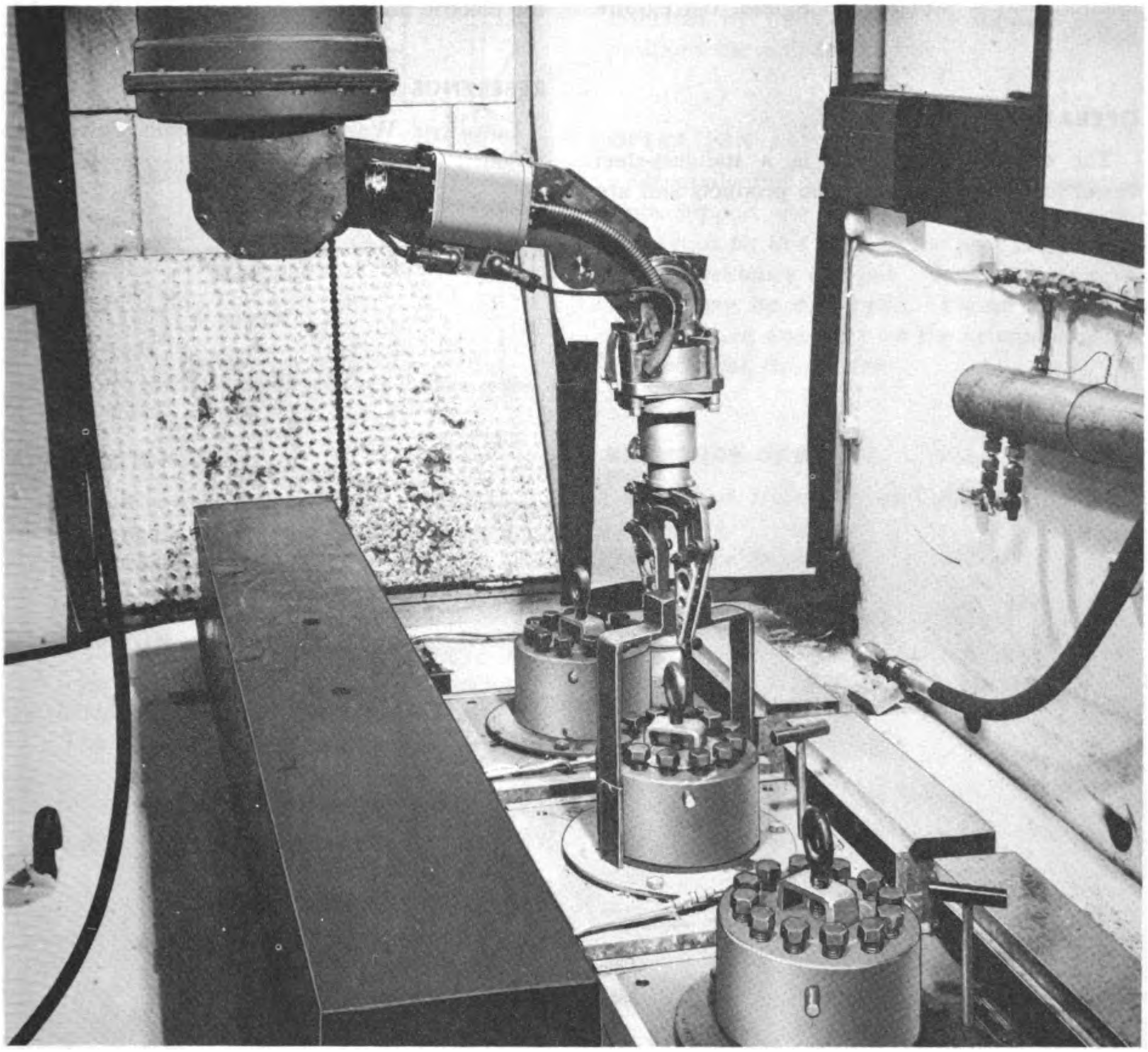
REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: L. G. Stang, Jr., W. D. Tucker, A. C. Rand, Jr., G. Strickland, and G. Selvin, Remotely Operated Chemical Processing Equipment, ORNL-52-10-230, October, 1953.

Patent Data: U.S. Patent 2,533,149, Precipitation Process and Apparatus Therefor, December, 1950.

REMOTELY OPERATED AUTOCLAVES



Installing autoclave head by means of manipulator-held wrench.

APPLICATION

These remotely operated autoclaves are used for corrosion testing of irradiated fuel and structural materials in 650°F water at saturation pressure. The autoclaves are loaded remotely, and adequate safeguards are provided to prevent the spread of contamination in the event of a leak.

DESCRIPTION

The three 5-in.-ID by 12-in.-deep autoclaves are located in a hot cell which provides 3 ft of magnetite concrete for shielding. Pressure switches are used to shut off the power when the pressure exceeds a predetermined value. Failure of the pressure switches causes a blowout diaphragm to exhaust the escaping steam into

a blowout tank to prevent the spread of contamination. The autoclaves are hooded and provided with a 500-cfm exhaust. A modified electric impact wrench, held and positioned by a manipulator, is provided to tighten the closure bolts.

OPERATION

The samples are placed in a stainless-steel vessel to confine the corrosion products and are moved into the autoclaves with a manipulator. The head is then placed on the autoclave and screwed on with a single wrench held in a manipulator. The closure bolts are then tightened with the electric impact wrench.

REFERENCE DATA

Location: Westinghouse Atomic Power Division.

SPOT HEATER

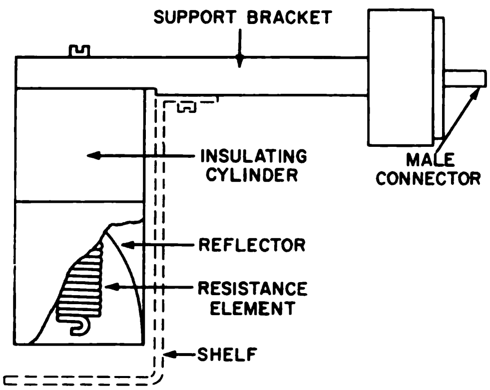


Fig. 1 Forty-watt spot heater, cutaway to show reflector and element.

APPLICATION

This unit is used for evaporation and firing of counting-plate samples in 2-in. lead-shielded manipulator boxes (see page 83).

DESCRIPTION

A 7½-volt a-c power supply is connected to the heater through the male connection (Fig. 1). The element radiates heat which is concentrated and focused by the dural reflector and insulated by the cylinder. A support bracket positions the unit in the box.

OPERATION

Generally this unit is used with a counting-plate support shelf. In practice the counting plate rests on this shelf as the heat is generated by the resistance element. Temperatures up to 800°C may be developed. Figure 2 shows a sampling-unit accessory for the manipulator box, incorporating this heater.

REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL	3F9393D	7J1851
	3F9352C	5J3822A
	3F9342A	3V4231
	3F9361	3V4243C
	3F9381B	

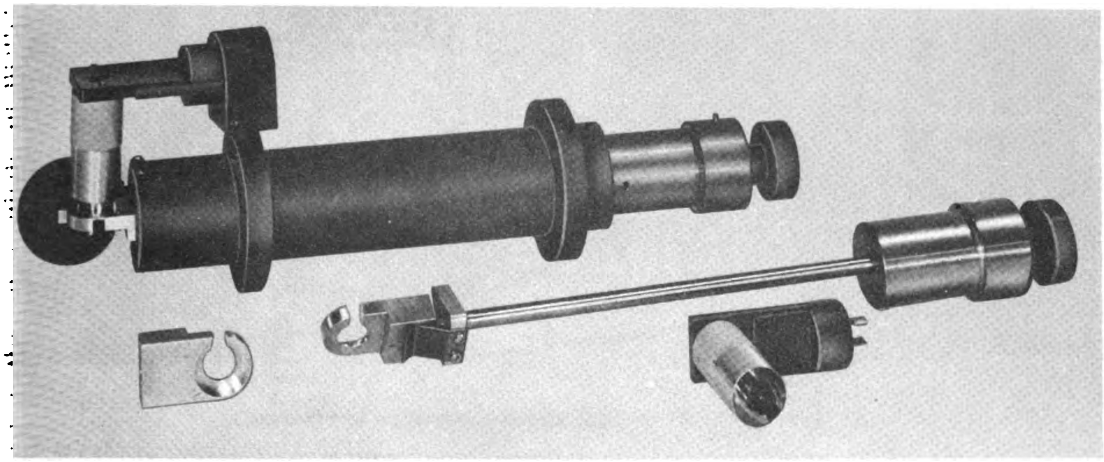
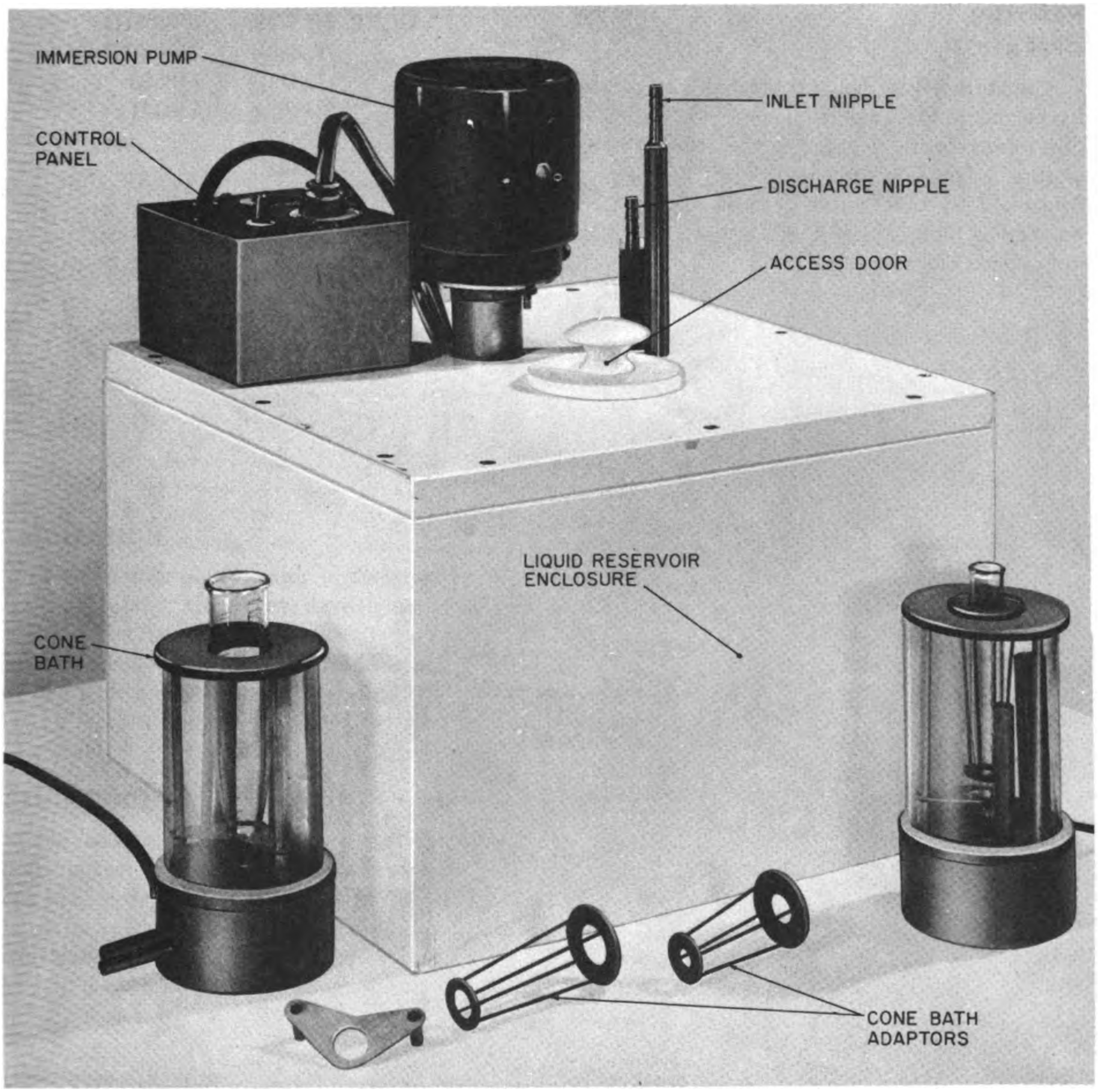


Fig. 2 Box sampling unit, assembled and disassembled, with spot heater.

COLD-BATH HEAT EXCHANGER



Cold-bath heat exchanger; cone baths and cone adapters in foreground.

APPLICATION

This device is used in 2-in. lead-shielded manipulator boxes and gloved boxes (see page 83) to supply the circulation of cooling fluids to temperature-controlled baths inside the box.

DESCRIPTION

Mounted on top of the liquid reservoir enclosure is a commercially available immersion pump. A power panel and extension cord provide 120-volt a-c current to the pump motor.

Access to the reservoir is through the door. The equipment to be cooled inside the manipulator box is connected to the discharge nipple and the inlet nipple with flexible tubing.

OPERATION

A mixture of dry ice and alcohol is circulated by means of the immersion pump through flexible tubing to the heat exchanger inside the enclosure. The temperature of the exchanger is controlled by a thermoswitch, which turns the immersion pump on and off as the cooling requirements change.

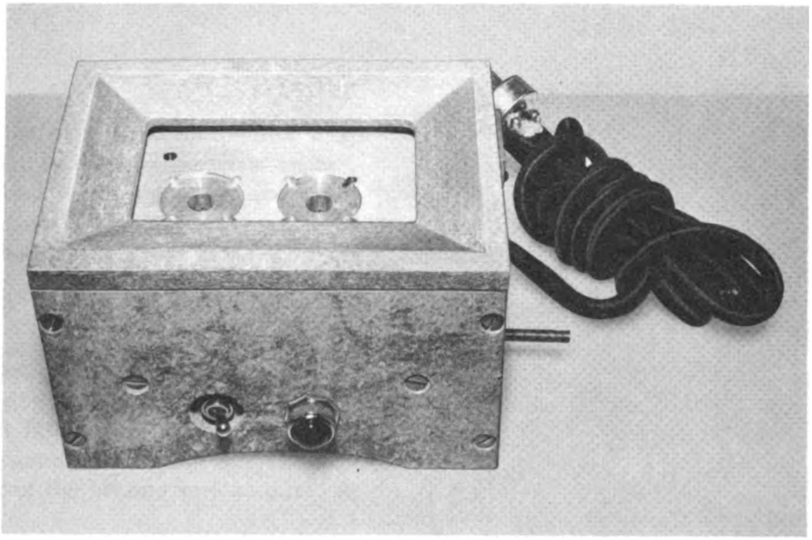
REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL	7J2374E	3V4051D
	7J2383B	3V4061D
	7J2392D	7J8333
	7J2402B	7J8341
	7J2412C	
	7J2421C	

COUNTING-PLATE HEATER



APPLICATION

The counting-plate heater is designed to dry counting plates after they have been mounted with organic samples. The heat is thermostatically controlled, and a gas jet allows the plates to dry with a cool center, preventing the spread of the sample over the plate.

DESCRIPTION

The heater consists of an aluminum block, housing two heating cartridges and a thermostat. A circular depression is milled in the block to hold the plates. A gas jet is directed toward the bottom of the plate through a hole in the block. Slots around the edge allow easy removal of the plates with tweezers. The heater unit is housed in a fiberboard box.

OPERATION

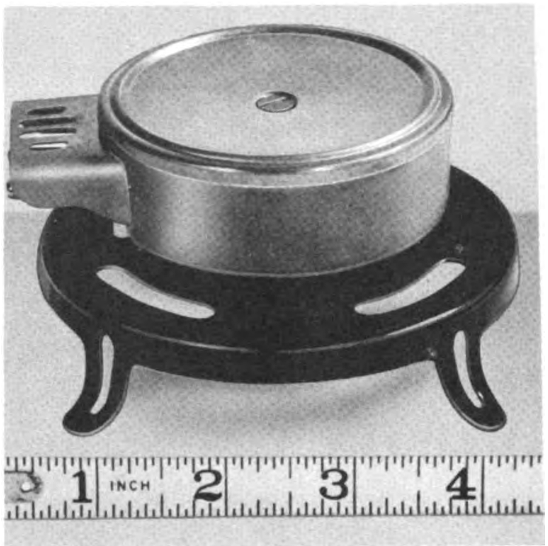
The thermostat is permanently set at a desirable temperature (180°F). The counting plate is mounted and placed on the preheated heater. A gentle flow of compressed air is allowed to flow around the plate until the liquid has evaporated.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawings: Assembly W-160616, D-110361, D-110363, D-113535.

MINIATURE DISPOSABLE HOT PLATE



APPLICATION

This midget hot plate is an inexpensive heating unit that may be disposed of when contaminated. It is used in gloved boxes and radiochemistry benches where contamination of equipment is likely.

DESCRIPTION

The midget hot plate consists of a base, body, and cap enclosing a porcelain housing for a wound 250-watt 110-volt d-c heating coil. The entire unit is assembled with one screw.

The diameter of the heating surface is 2½ in.

REFERENCE DATA

Location: Savannah River Laboratory.

HEATER-MIXER

Combined heater and magnetic mixer.

APPLICATION

Radioactive solutions contained in small beakers may be separately or simultaneously heated or mixed by this remotely controlled unit.

DESCRIPTION

The lower section consists of a standard magnetic mixer with the controls removed for remote operation. The upper section consists of a standard electric disk heater reassembled in a nonmagnetic aluminum or stainless-steel case and stainless-steel cover plate.

OPERATION

The beaker containing the solution is placed on the heater plate, and the heater-mixer controls are adjusted for the desired conditions.

REFERENCE DATA

Location: Brookhaven National Laboratory.

TONG STIRRER

APPLICATION

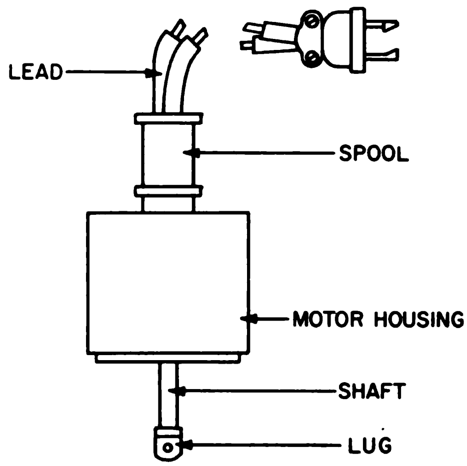
The tong stirrer is used for stirring operations in 2-in. lead-shielded manipulator boxes (see page 83).

DESCRIPTION

This unit consists of a motor housing through which extends a shaft terminating in the stirring-wire lug. At the top of the housing is a spool serving as a grasping handle for the tong fingers. The tongs are used to carry the stirrer around the confines of the box, or the stirrer may be clipped to the side of the box by a suitable mount. Power is introduced to the motor by the lead. The unit is 32 mm in diameter by 70 mm over-all height.

OPERATION

An electrical supply of 0 to 8 volts direct current provides power and speed control. A straight platinum wire is hooked through the lug to provide a stirring action. Violent agitation of a full 40-ml cone is obtained with maximum power. The stirrer easily disperses centrifuged precipitates during dissolving or washing procedures.



REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL 5J3832A
4J8951B
4J8961
7J5131
7J5141
7J5261
7J5271

ROD RUNNER ANL MODEL 3

ROTATING RINGSTAND ANL MODEL 2

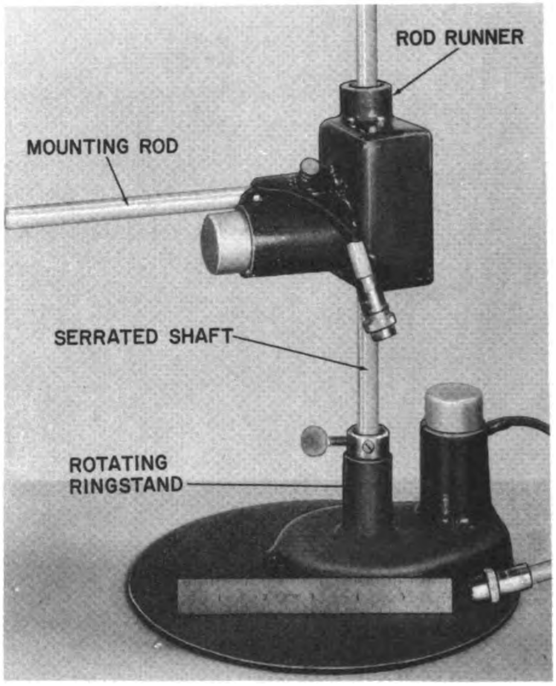
APPLICATION

These two devices provide remotely controlled movement for small equipment used in many hood and cave experiments. The rod runner is used to impart linear motion and the ringstand, rotary motion. Mounting sockets in each device allow apparatus to be easily attached or removed. The two devices may be used separately or together as illustrated.

DESCRIPTION

The rod runner consists of a small d-c motor geared down to a nylon roller to provide a peripheral speed of ½ to 2 in./sec. The nylon roller is spring-loaded against the serrated flat on a ½-in.-diameter vertical shaft, so that relative motion at that speed results. Usually the motion is used to raise or lower items attached to the rod runner, though it is possible to fix the rod runner and utilize the travel of the rod instead. The device is capable of a 20-lb thrust.

The ringstand employs an identical d-c motor to rotate a ½-in.-diameter socket at 1 to 5 rpm, providing the rod runner in the ringstand with 2° of freedom. Ordinary ½-in.-diameter vacuum framing rods may be used with the ringstand.



Rod runner mounted with rotating ringstand.

OPERATION

With a source of variable d-c voltage, these devices have been found very useful for performing simple manipulations in crowded interiors of shielded hoods or junior caves.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Rod runner, RCD-218; ringstand, RCD-219.

ROTATING REAGENT RACK

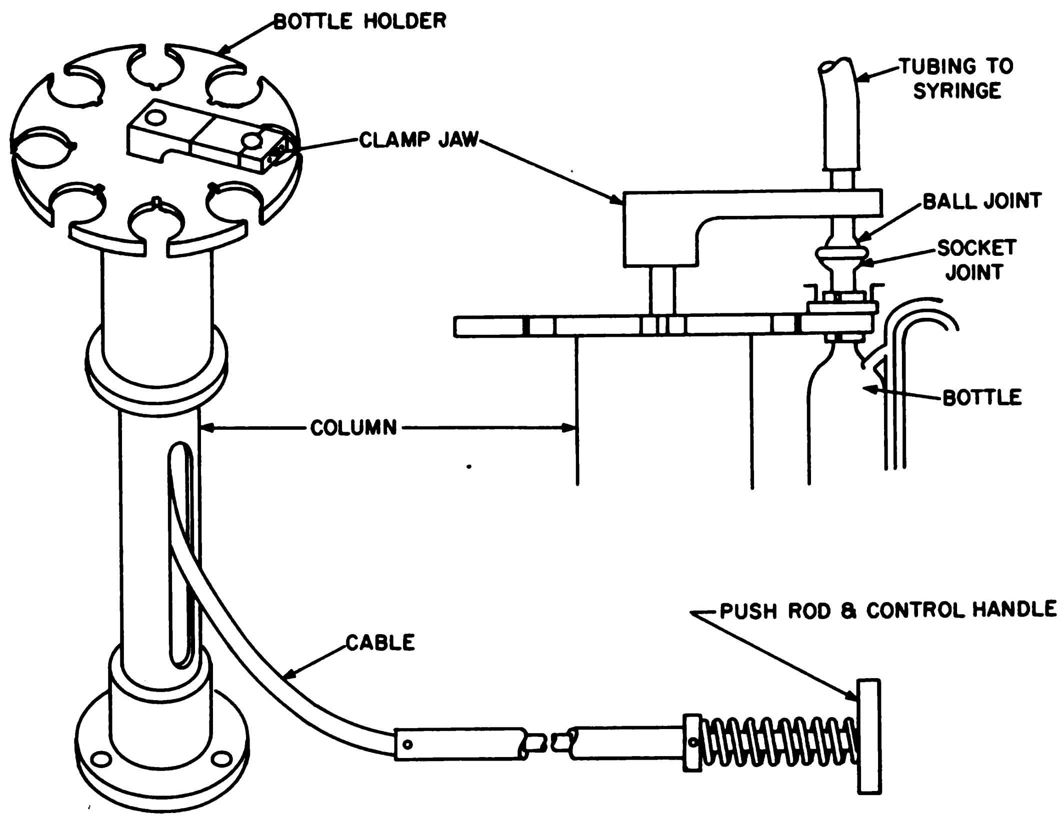


Fig. 1 Rotating reagent rack with detail of joint.

APPLICATION

This reagent rack is used in association with the chain-drive manipulator in a 2-in. lead-shielded manipulator box (see page 83). The rotating reagent rack facilitates the transfer of liquids to or from gooseneck bottles by means of suction or pressure. The rack (Fig. 1) is used to hold gooseneck bottles (Fig. 2).

DESCRIPTION

The rotating reagent rack consists of a column supporting a revolving bottleholder with places for eight gooseneck bottles. A clamp jaw is rotated and raised by a flexible shaft controlled by a handle outside the manipulator box. A standard ball joint is held in the clamp jaw and is connected at its upper end by plastic tubing to a syringe outside the box for suction or pressure. Bottle sizes up to 500 ml may be used in the bottleholder.

OPERATION

The clamped ball joint is raised and positioned over the socket joint of the selected bottle by advancing the spring-loaded push rod and turning the handle. When the push rod is retracted, the joints are engaged and both clamp and bottleholder may be rotated by the control into position over a receiving vessel. Pressure applied by the syringe discharges fluid from the bottle. Suction applied by the syringe draws liquid into the bottle. By substituting a micropipette for the

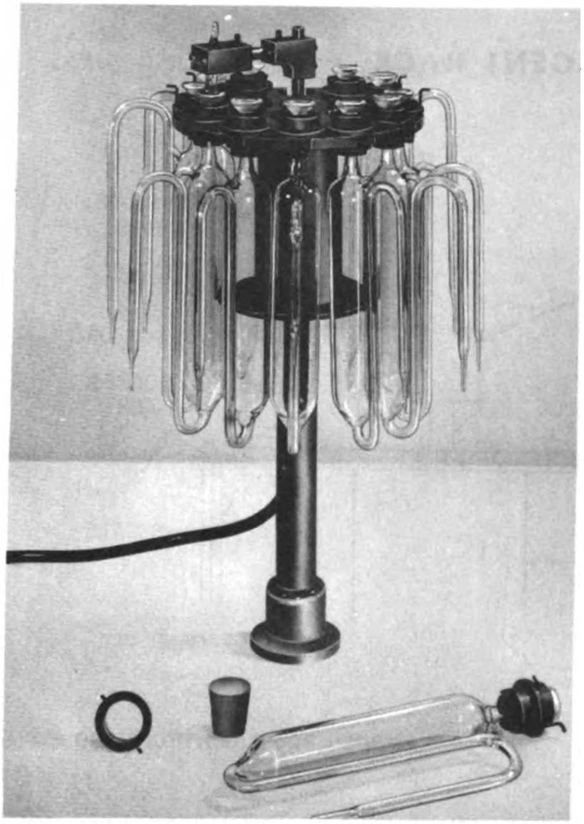


Fig. 2 Rotating reagent rack with gooseneck bottles.

discharge tip, volumes as small as 5 microliters may be measured.

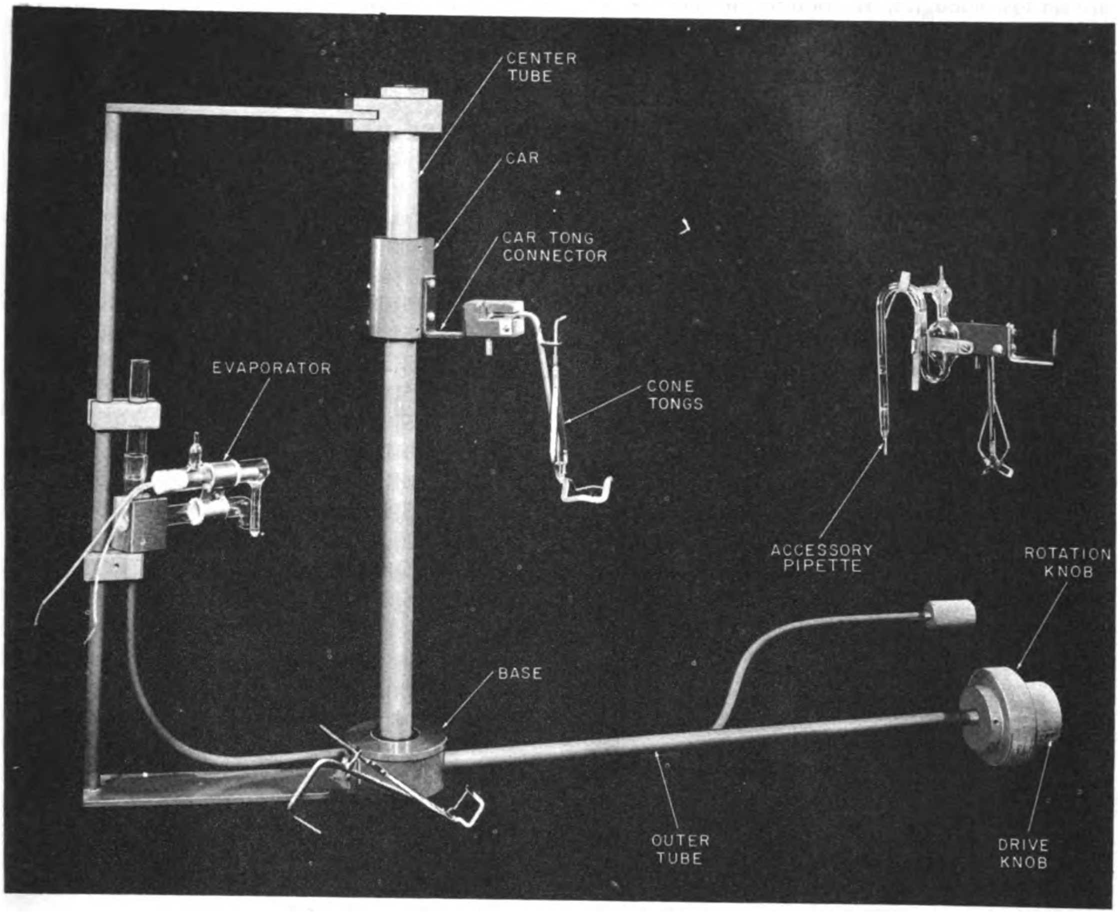
REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL	4J4983H	5J1712C
	4J4991C	5J1722F
	4J5002C	7J2541-2A
	4J5012C	4J2081B
	4J5021C	7J7102
	7J5031	8J1141
	7J4553	28-2981
	4J5051C	4J5032B
	5J5991B	4J5043A
	4J5071A	4J5112A
	4J5081A	7J5381C
	4J5091A	7J5391C
	4J5101A	7J5401A
	5J1704E	7J5411B

CHAIN-DRIVE MANIPULATOR



Chain-drive manipulator, schematic.

APPLICATION

This device is the central item of remote-control equipment in a 2-in. lead-shielded manipulator box (see page 83). Spring-loaded cone tongs are self-actuating and have 12-in. vertical travel and 360° rotation controlled by concentric shafts operated through the front of the shield. All other pieces of equipment are set up on intersecting circles on the box base, enabling the tongs to transfer cones to a turntable, cone baths (hot and cold), cone balance, well centrifuge, rotating reagent rack, and cone basket.

DESCRIPTION

The unit consists of a center tube and a car traveling vertically and rotating with the tube. Extending from the car is the car-tong connector for carrying the interchangeable cone tongs. Housed in the base are gears actuated by concentric shafts operating within the outer tube which pierces the shield wall. The rotation knob may be turned to provide unlimited rotation of the tongs about the center tube. The drive knob actuates a chain attached to the car through a slot in the center tube and provides vertical mo-

tion the full length of the center tube. Tong fingers have been designed to accommodate 15- and 40-ml centrifuge cones. The tong fingers are set low enough in relation to the car to allow cones to be introduced into a well centrifuge below the bottom of the box. A support (not shown) fixes the base and center tube firmly in the box. Over-all dimensions may be selected to suit the enclosure. Parts are generally machined of brass, with a baked phenolic resin coating for corrosion resistance.

OPERATION

Rotation of the knobs outside the shield, while the motion inside is observed through a lead-glass viewing window, will bring the tong fingers over the lip of a cone in a suitable holder. Once the fingers have engaged the top of the cone, spring tension holds it firmly and the cone may be lifted to a new position. To release the cone in its new position, further downward pressure against the top of the holder is required to trigger the fingers to the fully open position. The fingers must be retensioned by engaging them with some firm ledge before another cone may be picked up. If desired, the tongs may be replaced with a gooseneck pipette and the motions may be used to decant and discharge solutions from cones or other vessels.

REFERENCE DATA

Location: University of California Radiation Laboratory.

Reference Drawings:

UCRL	7J4956C	5J2171C	7J4983
	5J2012F	5J2181B	7J4991A
	5J2021D	5J2191B	7J5001
	5J2031B	5J2201D	7J3652D
	5J2041B	5J2211B	7J6351
	5J2062D	5J2221A	7J6361A
	5J2071B	5J2231D	7J3673D
	5J7721A	5J2241F	5J2321C
	5J2101C	5J2251E	5J2341C
	5J2111B	5J2261B	7J4962A
	5J2121D	5J2271B	7J4972A
	5J2141E	5J4741D	5J2361C

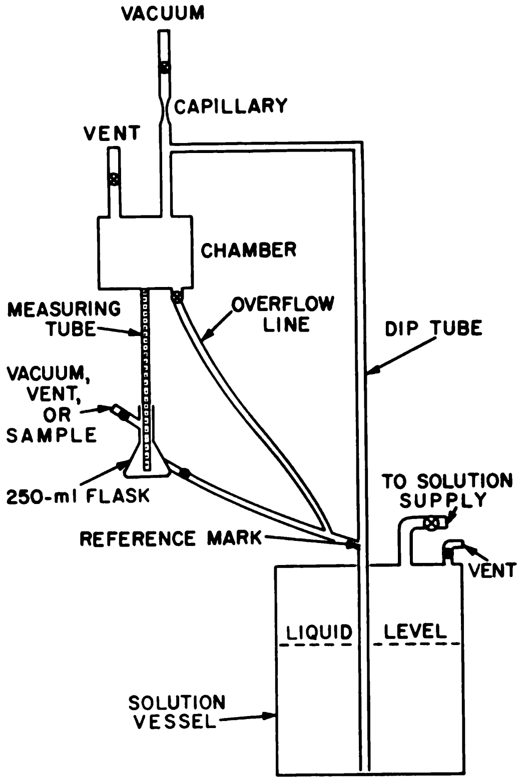
LIQUID-VOLUME MEASUREMENT APPARATUS

APPLICATION

This apparatus, using remote-control operational procedures, will measure the volume of solution in an opaque vessel. The equipment is especially useful in installations where highly corrosive or toxic materials are stored within sealed shielded enclosures.

DESCRIPTION

The apparatus is mounted adjacent to the storage vessel containing the liquid to be measured and is visible through windows in a control panel. A suitable flask with a side overflow arm is attached by its central neck to a measuring tube approximately 5 ft long. The upper end of the measuring tube is connected to a chamber fitted with overflow, vacuum, and atmosphere-vent outlets. The side arm of the flask and the chamber overflow connections are attached through suitable stopcocks or valves to the vessel containing the solution to be measured. A dip tube connected to the vacuum system is inserted in the solution vessel.



System for remote measurement of the volume of corrosive liquid in an opaque vessel.

OPERATION

Solution is drawn from the vessel through the side arm into the lower flask, upward through the measuring tube, and into the chamber by application of vacuum through the vacuum connection. By means of the stopcock in the vacuum line, the vacuum connection is closed and the chamber is vented to the atmosphere. Liquid in the chamber, the measuring tube, and the flask drains back into the vessel through the flask side arm, which is so positioned that the flask remains partially filled with liquid. The stopcocks in the flask side arm and overflow lines are closed, and the flask is vented to the atmosphere. Vacuum is applied to the chamber and to the dip tube in the solution vessel. When the liquid in the dip tube reaches a reference mark, the stopcock leading to the vacuum system is closed. Liquid in the measuring tube, which has been subjected to the same vacuum as that in the dip tube, rises a distance that is proportional to the rise of liquid in the dip tube. The volume of solution in the vessel is read from graduations marked on the measuring tube. This measuring tube is calibrated with known volumes of solution in the vessel. To check the solution-volume measurement, the chamber is

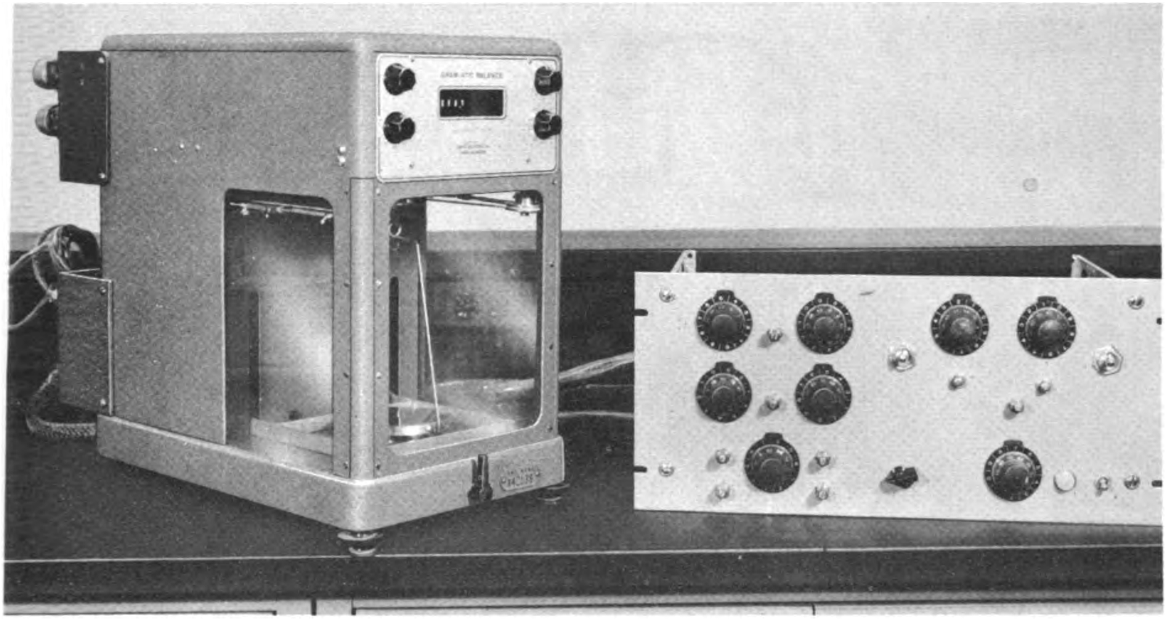
vented to the atmosphere and this forces the liquid back into the flask and into the vessel. The solution volume can then be remeasured as described.

The capillary in the vacuum line prevents the liquid from rising too rapidly in the measuring tube or in the dip line. The three-way stopcock in the flask will permit sampling of the solution to be accomplished.

REFERENCE DATA

Location: Mound Laboratory.
Reference Drawing: 5848.

REMOTE-CONTROL ANALYTICAL BALANCE



Balance and remote controls before installation.

APPLICATION

This modified standard balance is used to weigh metallurgical samples and other radioactive materials. A remote-control panel is located outside the hot cell, with the balance operating inside the cell. The balance will perform accurate weighings from 0.1 mg to 200 g.

DESCRIPTION

All controls, such as weight-shifting knobs, zero adjustments, and beam locks, are designed to operate by means of motors and potentiometers controlled by an electronic circuit. The side doors are opened and closed by motor-driven pulleys and cables. A vertical lifting device, used when hydrostatic weighings are required, is installed over the weighing tray for raising a vessel of carbon tetrachloride into position for submerging samples.

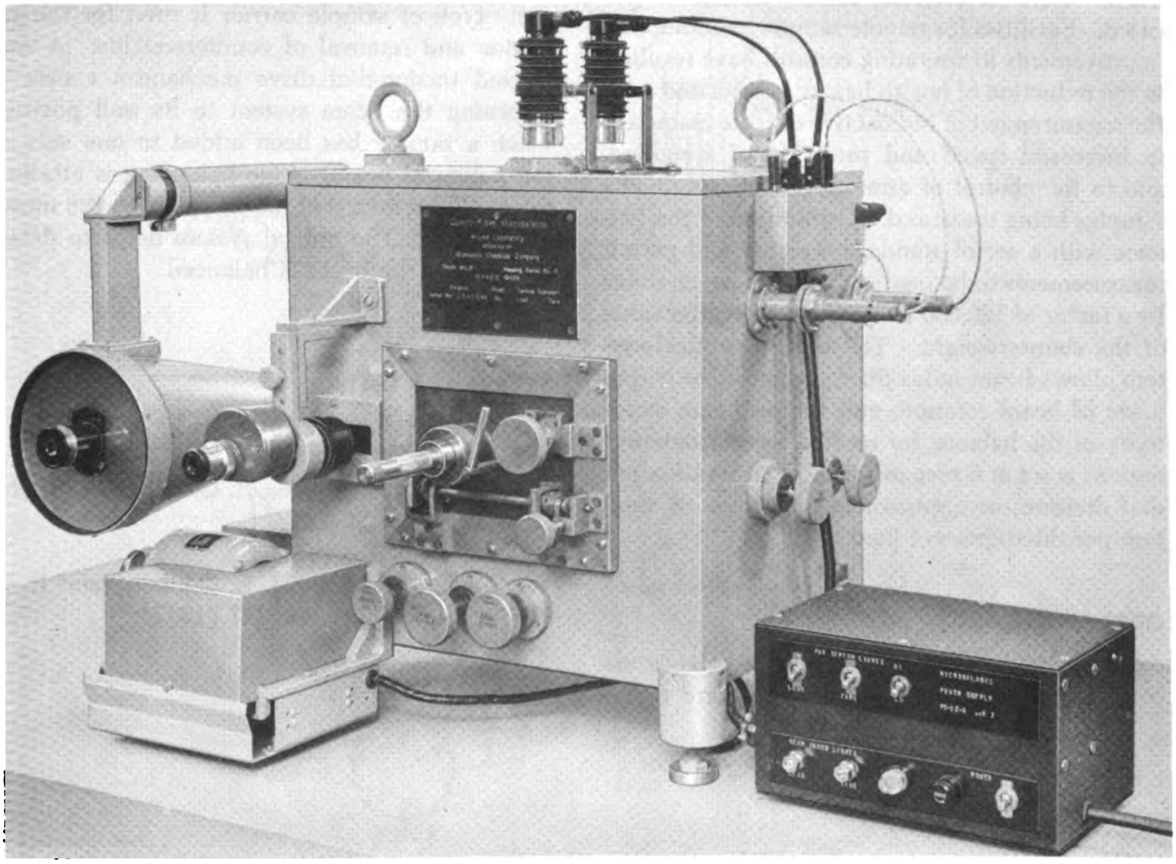
OPERATION

By operating knobs on the control panel an operator can open the side doors of the balance, insert the article to be weighed with a remotely operated manipulator, close the doors, and adjust weighing knobs until the exact weight is determined.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: E-6883.

QUARTZ-FIBER MICROBALANCE



Quartz-fiber microbalance and electrical controls.

APPLICATION

The quartz-fiber microbalance has been designed to accomplish the remote-controlled routine weighing of decimal microgram to milligram quantities of radioactive materials. It is equally useful for weighing nonradioactive materials in the same weight range, such as material which should be protected from the atmosphere or its environment. The range of operation of this balance may be shifted by replacing the torsion and suspension fibers with fibers of larger or smaller diameter. In addition to the routine measurement of small masses or mass differentials, quartz-fiber microbalances have been used in the following investigations:

1. Studies of the absorptive and hygroscopic qualities of surfaces.
2. Measurements of the density of liquids, vapors, and gases.
3. Measurements of the magnetic permeability of metals.
4. Measurements of the magnetic susceptibility of gases.
5. Determinations of the heat of reaction of chemical processes.
6. Determinations of the vaporization of refractory solids.
7. Examinations of selected materials to determine the possible influence of temperature upon weight.

DESCRIPTION

The microbalance is an improved torsion-fiber-type microbalance in which weighings are performed within a vacuumtight housing wherein the atmosphere may be controlled and duplicated. Facilities for remote sample handling and improvements in operating controls have resulted in the reduction of health hazards associated with the measurement of radioactive or toxic materials, in increased speed and precision of weighing, and in the control of atmospheric effects on the samples being measured. Calibration of the balance with a set of standard weights will permit measurements to be made of weights which differ by a factor of 120,000 without changing the value of the counterweight. The balance optical system allows beam index-fiber alignment to within 2 sec of beam rotation, and the optimum sensitivity of the balance for routine weight determinations is set at 60 sec of torsion-dial rotation per dial division, or approximately 240 sec of rotation per microgram of load.

OPERATION

The principles of operation of the balance are conventional in that sample weights are determined from the difference in force required to balance the loaded and unloaded sample support against the same counterweight. A sealed carrier conveys the sample to be weighed from a previous sample operation into the balance. The same type of sample carrier is used for the insertion and removal of counterweights. A motorized torsion-dial drive mechanism assists in returning the beam system to its null position when a sample has been added to one side of the balanced beam. Fine balancing is attained manually by means of an extension to the motor drive shaft. The optical system helps to determine when the beam is balanced.

REFERENCE DATA

Location: Mound Laboratory.

Reference Documents: R. G. Olt et al., MLM-1022, Dec. 7, 1954.

P. L. Kirk, R. Craig, J. E. Gullberg, and R. Q. Boyer, *Anal. Chem.*, **19**, 427 (1947).

REAGENT WEIGHING AND TRANSFER SYSTEM

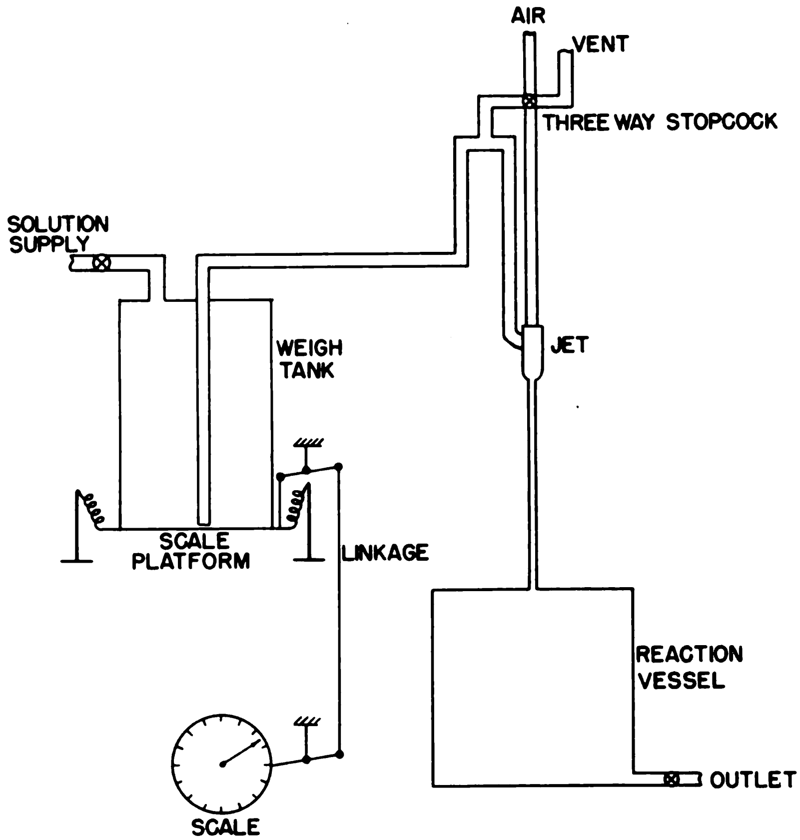


Diagram of weighing and transfer system.

APPLICATION

The reagent weighing and transfer system is used in the weighing of corrosive liquids stored in reagent supply tanks and in the transfer of the reagent to a reaction vessel. Remote control permits performance of these operations in an enclosed area.

DESCRIPTION

The equipment consists of a reagent supply tank supported on a scale platform, linkages connecting the scale platform to a remote scale indicator, and means whereby quantities of the reagent may be withdrawn, by remote-control methods, from the supply tank and transferred to a reaction vessel.

OPERATION

The quantity of reagent to be supplied to the reaction vessel is controlled during transfer by observing net weight changes on the scale indicator. Transfer is made by remote actuation of the three-way stopcock in the transfer line. With the three-way stopcock in the vent position, no reagent is transferred because of the elevated loop in the transfer line. When transfer is desired, the vent connection of the stopcock is closed and the stopcock is positioned to admit compressed air to the jet. The flow of air

through the jet creates a partial vacuum, drawing reagent material from the reagent storage tank through the elevated loop into the reaction vessel. When the loop is filled, the reagent will flow into the reaction vessel because the arrangement forms a siphon. Once the siphon is formed, the air to the jet may be shut off by moving the stopcock to the closed position. Reagent flow will continue until the stopcock is turned to the vent position, breaking the siphon action in the transfer line.

REFERENCE DATA

Location: Mound Laboratory.
Reference Drawing: 5849.

PROFILE RECORDER

APPLICATION

The profile recorder was designed to facilitate the study of surface and over-all distortions of irradiated samples. The recorder will handle samples up to 3 in. wide, 10 in. long, and 4 in. thick and of any regular or irregular shape. Effects on surface profile can be studied before and after irradiation.

DESCRIPTION

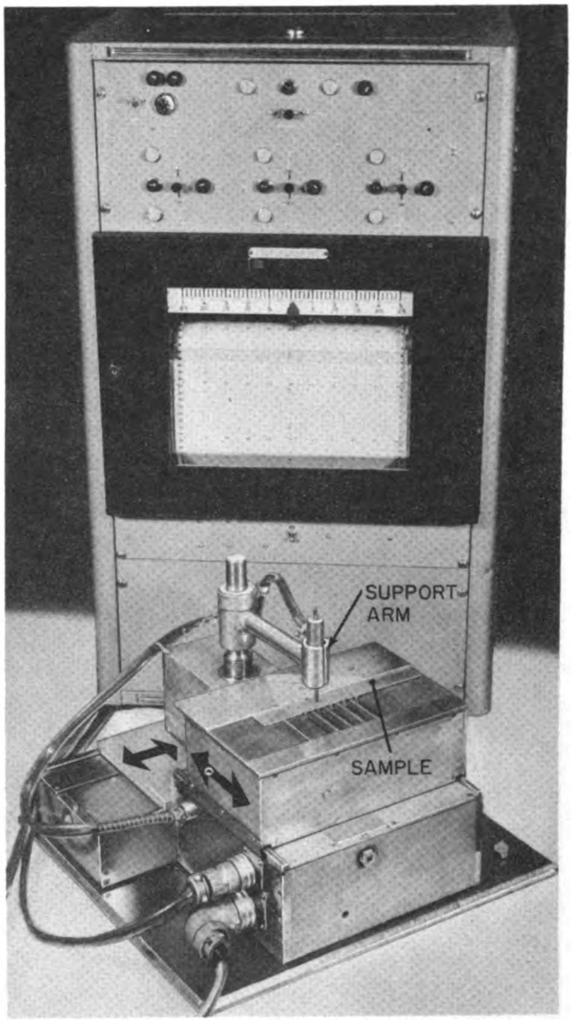
The instrument is made up of two separate units. The first is the actual profile mechanism with all necessary motor drive, clamps, maximum travel switches, and other related parts, which are located behind a thick concrete radiation shield. All drives have been designed with anti-backlash devices to eliminate machine error from the actual data.

The second unit of the mechanism consists of the operating and control panel with all switches, indicating lights, and a recorder and is installed outside the hot cell.

OPERATION

The samples to be tested are placed on the equipment by the use of remote-controlled tongs. Samples are positioned and clamped with the aid of five microswitches mounted approximately 7/8 in. apart on a motor-driven slide. The normally closed sides of the single-pole double-throw switches are connected in series with the motor, and the normally open sides in parallel with a pilot light. When the samples are properly positioned and clamped, the microswitches break the motor circuit and make the pilot light indicating circuit.

The carriage containing the sample has longitudinal motion. Traverse motion of the support arm, which contains a variable microformer and stylus, is obtained by the use of a motor geared to a lead screw. The support arm is elevated and lowered by a second lead screw geared to a motor. The profile of the scribed surface of the sample is plotted on a recorder, which is scaled up vertically by a factor of 100 to 1.



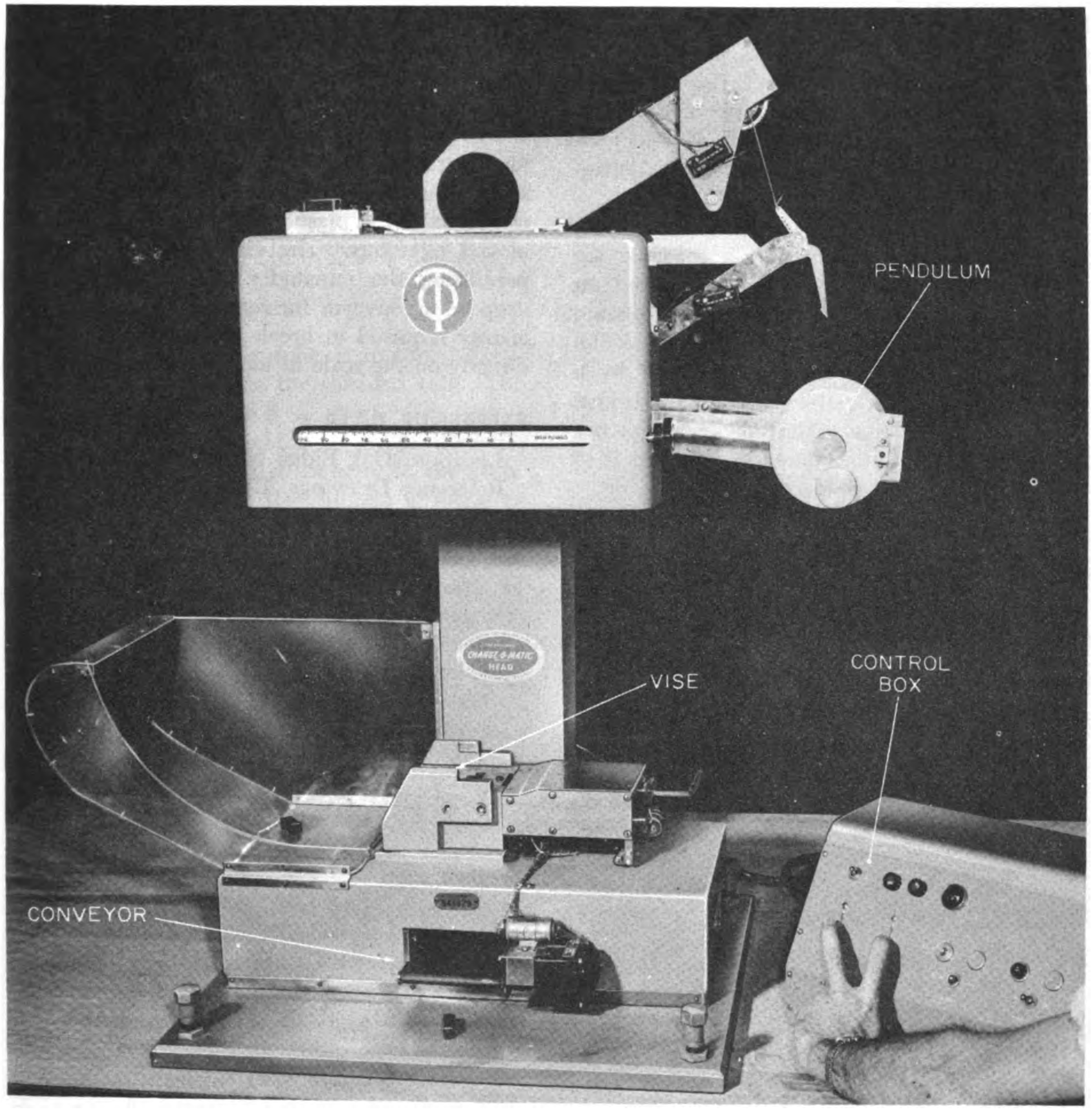
Profile mechanism, control panel, and recorder before installation.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-6487, D-6488, D-6489, D-6490, D-6491, D-6492, D-6493, D-6494, D-6495, D-6496, D-6502, D-6503, D-6514.

IMPACT TESTER



Impact tester and control box before installation in cell.

APPLICATION

The impact tester was designed to determine the toughness of radioactive test specimens. Impact is furnished by the swing of a pendulum of known weight. The difference between the energy supplied (pendulum weight times height of fall) and that remaining after impact (weight times height of rise) is the energy required to break the specimen.

DESCRIPTION

The impact tester is a standard tester modified to operate remotely behind a 3-ft concrete wall.

The vise screw is driven by a fractional-horsepower motor. The motor pivots on its axis to contact a cutoff switch after a predetermined clamping load is applied by the vise. This arrangement ensures uniform and predetermined vise gripping pressure regardless of the thickness of the specimen. A solenoid-operated trigger releases the pendulum.

Because of the time required for the pendulum to come to rest after releasing, a special reset arm is pivoted on a hollow pin supported on bearings mounted in the frame of the testing machine on the same center of rotation as the pendulum. The arm, which is actuated by a motor drive with a variable-pitch pulley to give constant load and maximum efficiency, catches the pendulum while in motion and returns it to the latching position.

A conveyor with motor drive is installed in the base of the machine just under the vise.

A plastic catcher with rubber strips catches half of the broken sample.

A control box with necessary controls is located outside the cell.

OPERATION

Tongs are used to convey the radioactive specimen to the power-driven vise, where it is clamped into place. The pendulum is unlatched and breaks the clamped specimen. The pendulum is then returned to its latched position for succeeding tests. Half of the broken specimen is caught in the plastic catcher and may be removed by tongs. The vise jaws are released, permitting the remainder of the specimen to drop on a conveyor for removal by tongs. The energy required to break the specimen is read directly on the scale in inch-pounds.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-6962, D-6963, D-6964, D-6965, D-6966, D-6967, D-6968, D-6969, D-6970, D-6971, D-6972, D-6973.

REMOTE VACUUM CATHODIC ETCHER

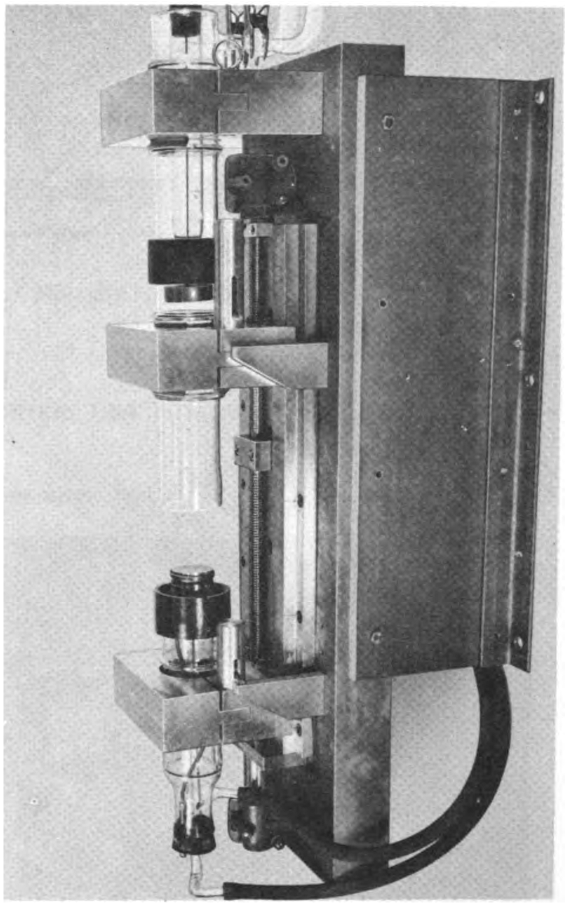
APPLICATION

A remote vacuum cathodic etcher has been constructed for etching radioactive metals. This system will produce etches on metals with clean surfaces for macro- and microscopic studies. This etcher can also be used for preparing surfaces for optical and electron microscopy studies.

DESCRIPTION

The vacuum etching tube is mounted vertically on the wall inside the shielded cell. The cathode and anode are 6 in. apart. The water-cooled zirconium cathode is 1½ in. in diameter, with the zirconium sealed directly to the glass. The tube surrounding the cathode is made of 2¼-in.-ID Pyrex tubing.

The vacuum and power unit are located outside the cell. The vacuum unit is capable of producing a vacuum pressure of 10^{-5} mm Hg. A facility has been incorporated for admitting argon to the etching tube directly and maintaining a continuous flow of argon at low pressures, 10^{-2} to 10^{-1} mm Hg, while etching. The power unit is capable of supplying up to 5000 volts at 30 ma.



OPERATION

The mechanically polished sample is placed on the zirconium cathode, which is then raised until a vacuum seal is produced by the neoprene gasket. After the sample has been outgassed under high vacuum for 10 to 15 min, argon is admitted to the cathode tube, maintaining the pressure at 4 to 5×10^{-2} mm Hg. When the system is flushed for about 5 min, the sample can be etched. Uranium has been etched satisfactorily at 2000 volts and 10 ma at 65 to 70 μ argon pressure. The etching times have been from 5 to 20 min. The longer the etching time, the more relief produced and the better the macroetch.

When the center section of the Pyrex tubing becomes blackened from the sputtered metal, it can be replaced by lowering the cathode and then lowering the center tube section until the clamp supporting it is automatically rebased. The clamp is then opened, the used section removed, and a new tube inserted.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Document: T. K. Bierlein, Cathodic Vacuum Etching of Uranium, HW-32676, Aug. 11, 1954.

DOUBLE CRYSTAL X-RAY DIFFRACTION UNIT

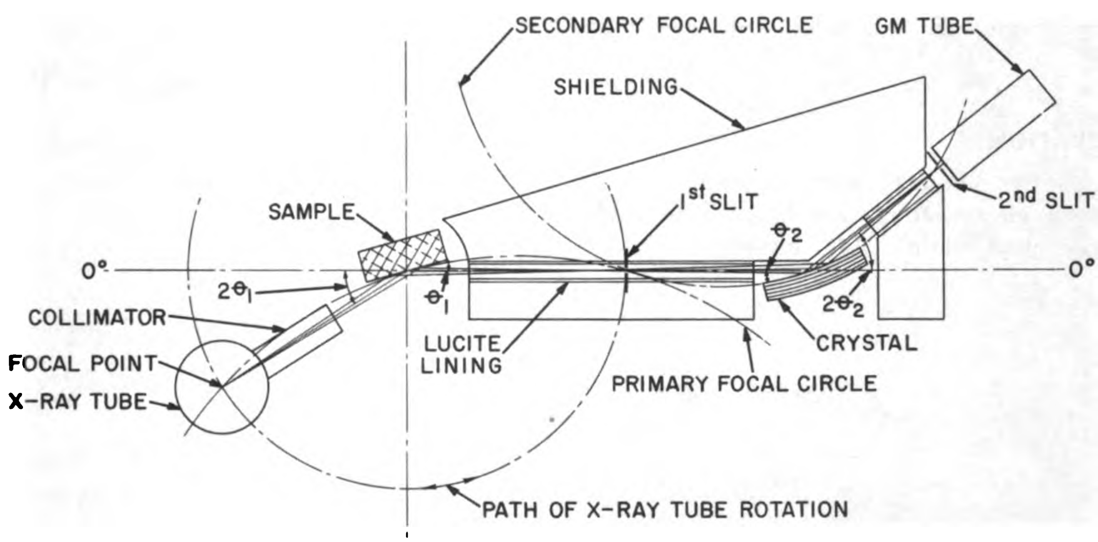


Fig. 1 Double-diffraction arrangement.

APPLICATION

The x-ray diffraction unit utilizes a double-diffraction technique for the study of the crystalline properties of pile irradiated materials. Both fissionable and nonfissionable materials can be investigated to determine the type and degree of induced radiation damage. Other studies such as identifications and preferred orientation determinations—routinely performed on nonradioactive materials—can be carried out with this unit.

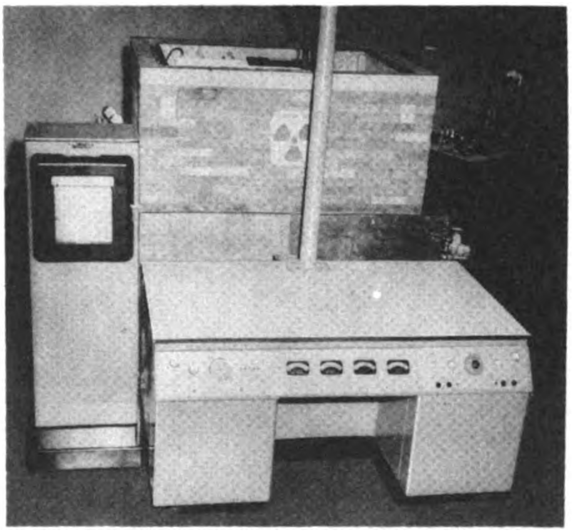


Fig. 2 Double-diffraction cell.

DESCRIPTION

In normal diffractions units the geometry is such that the path of the incident x rays is constant, while the diffracted path is variable. The same relative geometry is retained if the positions of the x-ray source and detector are exchanged. For the hot-laboratory diffraction unit this latter technique has been adopted with the addition of a monochromating crystal in the diffracted beam. This crystal is set at the correct Bragg angle to diffract, a second time, the monochromatic x rays from the x-ray tube. Since all but a negligible amount of the radiation emanating from the radioactive specimen has energies which differ from that of the x rays, the crystal acts as a "discriminator" and only the diffraction pattern of the specimen is recorded. Lead (Fig. 1) is placed between the sample and the detector to absorb the straight-line radiation. An aperture is cut through the lead and lined with

a beta-absorbing material to provide a path for the x rays. The equipment (Fig. 2) includes the power supply, the recorder, and the cell which contains the x-ray tube and goniometer. All controls of the modified goniometer are placed through the 6-in.-thick lead walls of the cell.

OPERATION

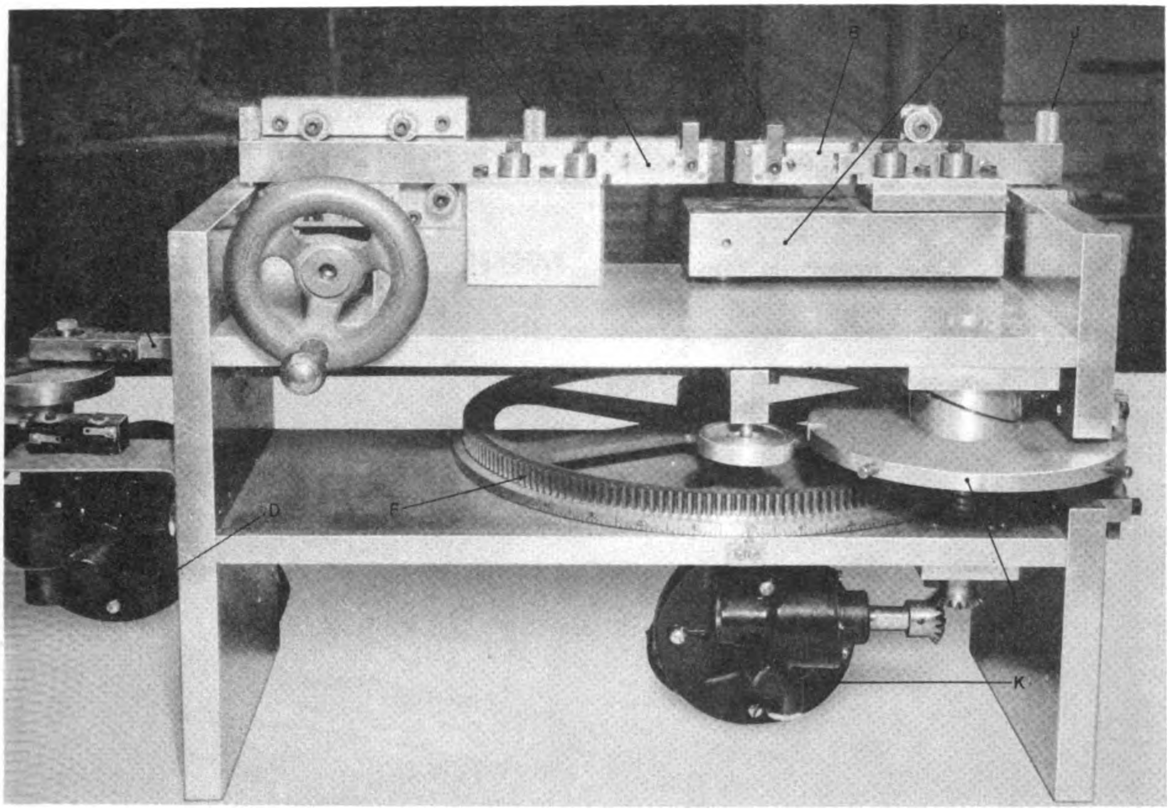
After the diffraction unit has been correctly aligned, all operations are handled remotely. The control console and recorder are conveniently placed and are operated directly. Specimens are prepared in other specialized metallographic cells and transferred to the x-ray cell in a lead cask.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Document: W. V. Cummings, D. C. Kaulitz, and M. J. Sanderson, *Rev. Sci. Instr.*, **26**, 5 (1955).

REMOTE BEND TESTER



Front view of bend-testing machine. *A*, stationary jaw; *B*, moving jaw; *C*, clamps; *D*, cyclic bend motor; *E*, gear rack; *F*, oscillating gear; *G*, moving arm; *H*, pin; *J*, pin; *K*, fracture bend motor; *L*, clutch.

APPLICATION

The remote bend tester was developed for performing cyclic bend tests in the plastic range and full 90° fracture bend tests. The cyclic test specimen can be deflected up to a $\pm 40°$ range at a rate of 1 cycle/sec. The 90° fracture test is motor-driven at a constant speed of 60°/min.

The maximum sample length that can be accommodated is 4 in., and the maximum test-sample cross-sectional area is 0.0625 in.^{2} The sample holding jaws can be modified for any cross-sectional shaped specimen.

The specimen can be inserted and removed from the machine with master-slave manipulators, and the machine can also be remotely converted from cyclic testing to 90° bend testing and vice versa.

DESCRIPTION

As illustrated, the stationary jaw (A) and the moving jaw (B) both swing open at the ends to admit the test specimen, and the clamps (C) tighten the jaws when the specimen is in position.

The motor (D) operates a gear rack (E), which in turn oscillates the gear (F). The moving arm (G) is connected to the gear shaft and oscillates with the gear. This then oscillates the jaw and flexes the test specimen. Both jaws can

be moved in and out for sample insertion and are held in testing position by the pins (H) and (J).

The second motor (K) is used for the 90° fracture bend tests and can be engaged to rotate the jaw by disengaging the gear rack and engaging the clutch (L).

The bend tester is 26 in. long, 15 in. wide, and 15 in. high.

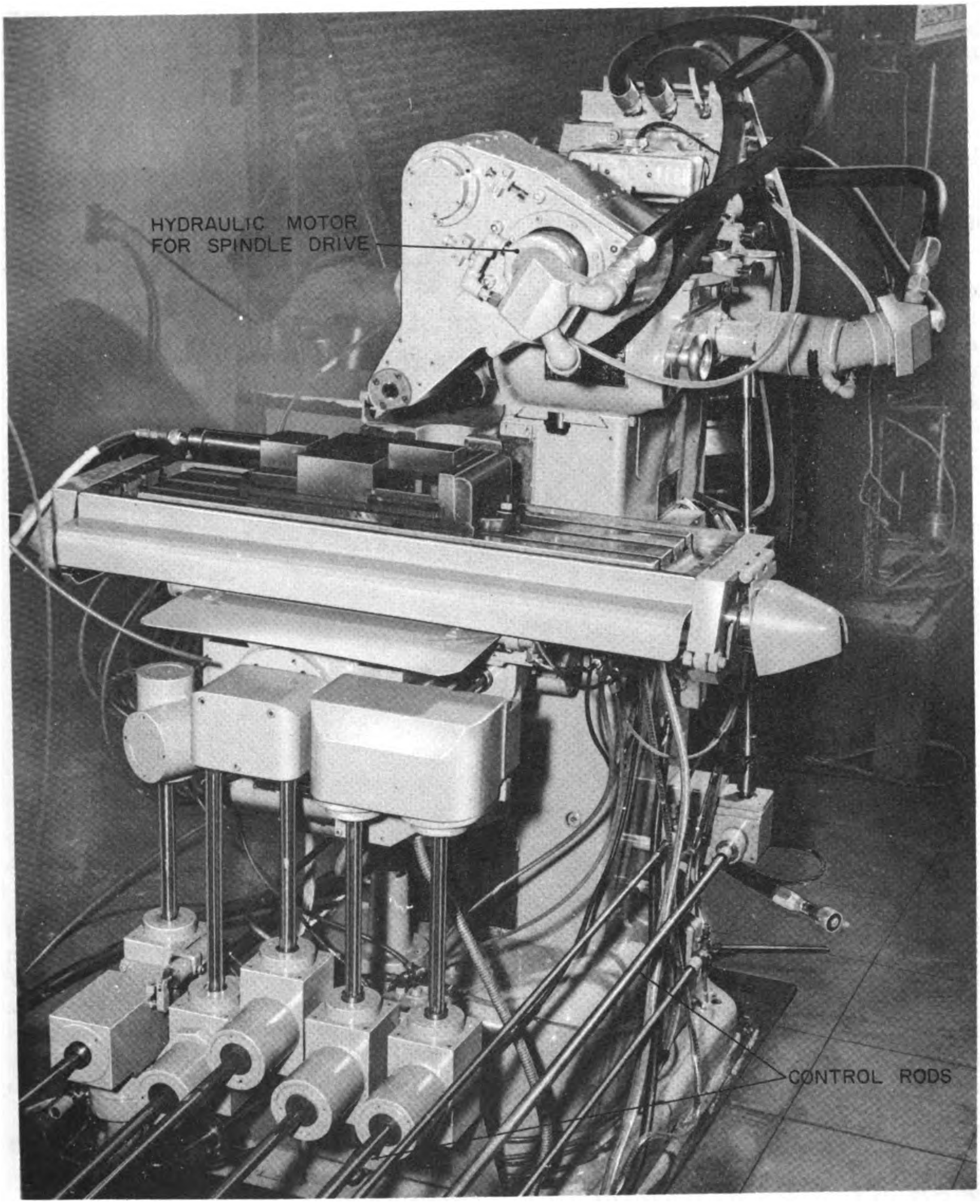
OPERATION

To insert the specimen the jaws are opened and the sample is placed in position. One jaw is then clamped securely, and by moving the jaws together or apart, the correct bend section position is located. The other jaw is then clamped, and both jaws are locked into position by the locating pins. The selection of a cyclic flexion test or a 90° fraction bend test is made by engaging either the rack (cyclic) or the clutch (90°). The test is run for the desired number of cycles or degrees of bend, and the sample is removed by loosening the clamps. The number of cycles run is counted by an electrical counter, and the degree of bend is obtained from an indicating dial.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: KAPL T-7A8556.

REMOTE-CONTROL MILLING MACHINE



Miller is shown before installation.

APPLICATION

The remote-control milling machine was converted and designed to reduce hot subassemblies into small usable metallurgical specimens. This is accomplished by cutting and grinding in preparation for the final operations of lapping and polishing.

In addition to performing any operation which a standard miller will perform, this machine can also be used for cutoff grinding.

DESCRIPTION AND OPERATION

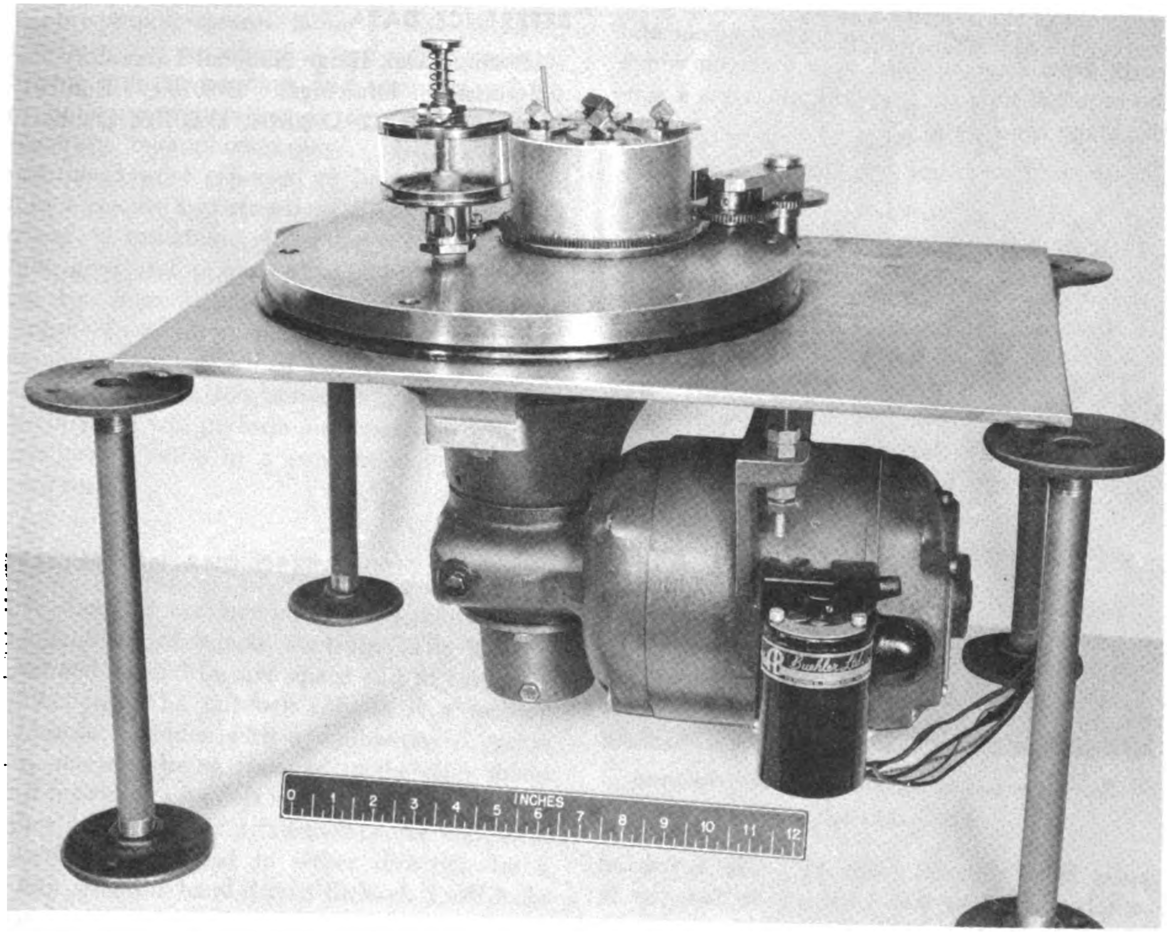
A commercial-type miller has been modified for either milling or surface grinding by holding the traverse screw to the table by three-jaw drill chucks. When closed, they hold the screw in tension; when open, they allow the table to move without touching the screw. When the screw is disconnected, the table is driven by hydraulic cylinders on both sides. Chucks are opened and closed by a special tool on the manipulator.

The grinding wheel and its hydraulic drive are mounted on the overarm. Either the grinder or an arbor support can be brought into position by rotating the overarm, which can also move horizontally. Manual control of traverse, cross-feed, and vertical motion is through bevel gears and splined shafts. A clutch disengages the traverse power feed. An auxiliary vertical power feed consisting of a hydraulic motor is built into the unit. Hydraulic power for all but the spindle grinder is supplied by a motor-driven pump inside the column.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: Assembly E-7375.

REMOTE METALLOGRAPHY POLISHING WHEEL



APPLICATION

The remote polishing wheel is used to accomplish the final stages of metallographic-specimen preparation prior to microscopic examination. While its primary purpose is the preparation of a wide variety of metals for microscopic examination, it has also been used in preparing flat and suitably polished surfaces for the x-ray diffraction studies of large crystals.

DESCRIPTION

This machine is an adaptation of a standard cloth-covered polishing wheel. The specimens are held by an eccentrically mounted turret which revolves counter to the rotation of the polishing cloth. The turret holds four mounted metallographic samples which are fixed in their horizontal position relative to the turret by virtue of the close tolerance between the sample and the turret holes (0.001 in. maximum). The samples are free in the vertical direction and are weighted against the polishing wheel by the specimen holders. The holders are hollow cylinders with a permanent magnet at their lower end to facilitate removal of the specimen, a hollow center to accommodate lead shot for weighting, and a shaped top used to rotate each specimen one-quarter turn about its own axis for each complete rotation of the turret.

OPERATION

A mounted specimen, which has a ferritic identification disk embedded in the back of the mount, is remotely attached to the specimen holder. The holder and specimen are then inserted in the turret. The polishing wheel and turret drive are controlled by a timer on which the required time for a specific metal at a specific stage can be set.

Variables influencing the quality of the surface polish are texture of the polishing cloth, size of abrasive, weight of specimen holder, and time of operation.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: E-20700, E-20701, D-20702, D-20703, D-20704, D-20705, D-19257.

REMOTE-CONTROL LATHE

APPLICATION

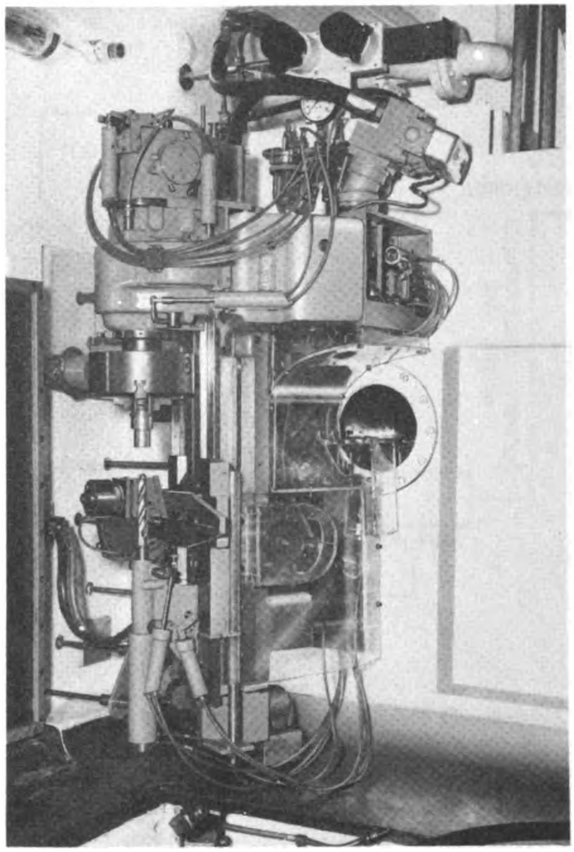
This remote-control lathe is for preparing specimens for metallurgical tests such as tension, torsion, impact, bending, and hardness and for preliminary preparation of samples for grain-structure microphotography. Many of these specimens were expected to be prepared from fuel elements and structures that had been exposed to radiation. In some cases irradiated specimens used in one test need further machining for subsequent tests or for microphotography. In addition, the lathe may be used to repair equipment which has been exposed to radiation and is too active to be worked on directly. It will perform any operation which a comparable lathe in a conventional shop will perform.

DESCRIPTION AND OPERATION

A standard commercial lathe is modified by the addition of remote controls. The lathe is mounted on end to save space and to ease chip collection. The tailstock spindle is a moving hydraulic cylinder with a double-ended piston rod, one end being fastened to the chip shield and providing oil inlets into the cylinder and the other end acting as a tailstock-center knockout. Pressure is supplied in either direction by a pump which is hand-driven through a self-locking worm gear. Spring-loaded reservoirs on both sides of the closed hydraulic loop take up slack in the system. A similar system drives a fixed-vane motor to rotate and clamp a four-position automatic-indexing tool-post holder.

To clamp the work a collet chuck is stopped so that the chuck key can be engaged. The chuck key is linked to a lever outside the cell. The chucks are operated by bevel gears and can be changed with a manipulator tool.

Headstock change-gear levers are connected through simple levers to handles outside the cell, and the spindle gear is operated by an air cylinder. The carriage and cross-feed rod may be driven either by hand through bevel gears at the end of the lathe bed or by a variable-speed motor and clutch also mounted on the lathe end. Feed-rod engagement, cross-feed, and carriage-drive levers are actuated by air cylinders, and the carriage is counterbalanced by an air cylinder mounted behind the bed. The lead-screw nut is engaged by a fixed-vane air motor. Back gear and binders are actuated by double-acting air cylinders. All pneumatic units are operated by solenoid valves.



Remote-control lathe mounted on end within cell.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawing: E-7304.

ABRASIVE CUTOFF MACHINE

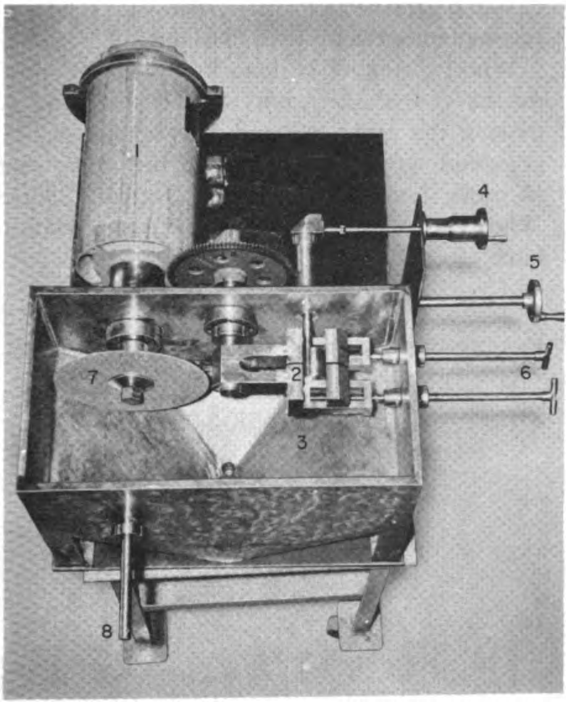


Fig. 1 Abrasive cutoff machine with box lid removed. 1, 2-hp 1800-rpm motorized grinding spindle; 2, double vise; 3, stainless-steel box; 4, micrometer thickness gauge; 5, feeding crank; 6, vise adjusting rods; 7, arbor and abrasive wheel; 8, arbor wrench.

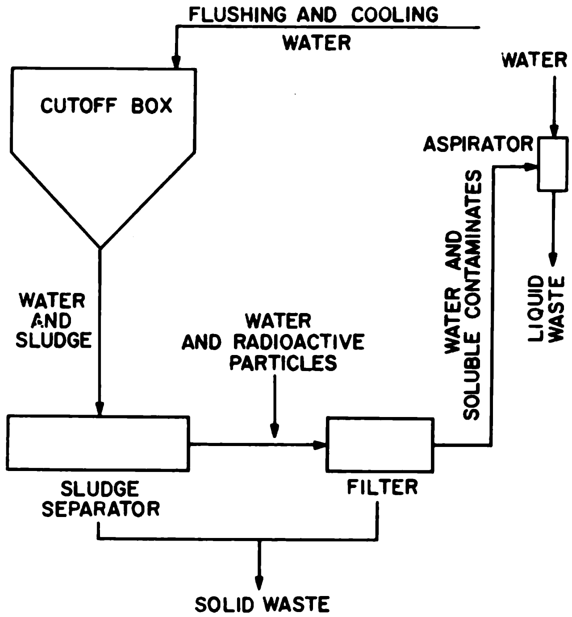


Fig. 2 Cutoff machine waste-flow diagram.

APPLICATION

This abrasive cutting unit is capable of producing samples from radioactive material for metallurgical, chemical, and physical investigations without undue exposure of personnel to radioactive contaminants. The design of the cutting unit makes possible the transverse and longitudinal sectioning of cylindrical or flat materials for metallurgical or chemical examination. In addition, square or rectangular physical-property test samples may be sectioned with good control of sample dimensions and shape. Cutoff box dimensions, wheel dimensions, and wheel diameter restrict the maximum dimensions of material which can be sectioned to approximately 2½ in. square by 12 in. in length. Special provisions are incorporated in the design to provide for separation and disposal of radioactive waste, changing of wheels, and protection of personnel during maintenance.

DESCRIPTION

The cutoff machine (Fig. 1) consists essentially of a driven shaft with an arbor-mounted abrasive wheel and a double-vise work-holding mechanism, all surrounded by a stainless-steel box.

The waste-flow diagram (Fig. 2) shows the filtering system for separation of the cutting waste from the cooling and flushing water. The bulk of the radioactive cutting residue is removed by a gravity-type separator, and the fine suspended particles are removed by a cotton filter. A lead cask, with a minimum shielding of 3 in. of lead, is used to shield the separator during waste collection and disposal. In addition to cell shielding, 2 in. of lead sheet is attached to the outside of the stainless-steel box to reduce the normal radiation level for maintenance.

OPERATION

Material to be sectioned is placed in the vise with a manipulator and positioned for desired specimen thickness with the micrometer thickness gauge. The vise jaws are then tightened and vise adjusting rods disengaged. Next, sufficient tap water is run into the box so that the material is completely submerged during sectioning. A box lid is then lowered into position by means of a hydraulic cylinder to seal the box. Feeding the material into the wheel is accomplished by rotating the feeding shaft that operates a worm gear attached to the vise shaft.

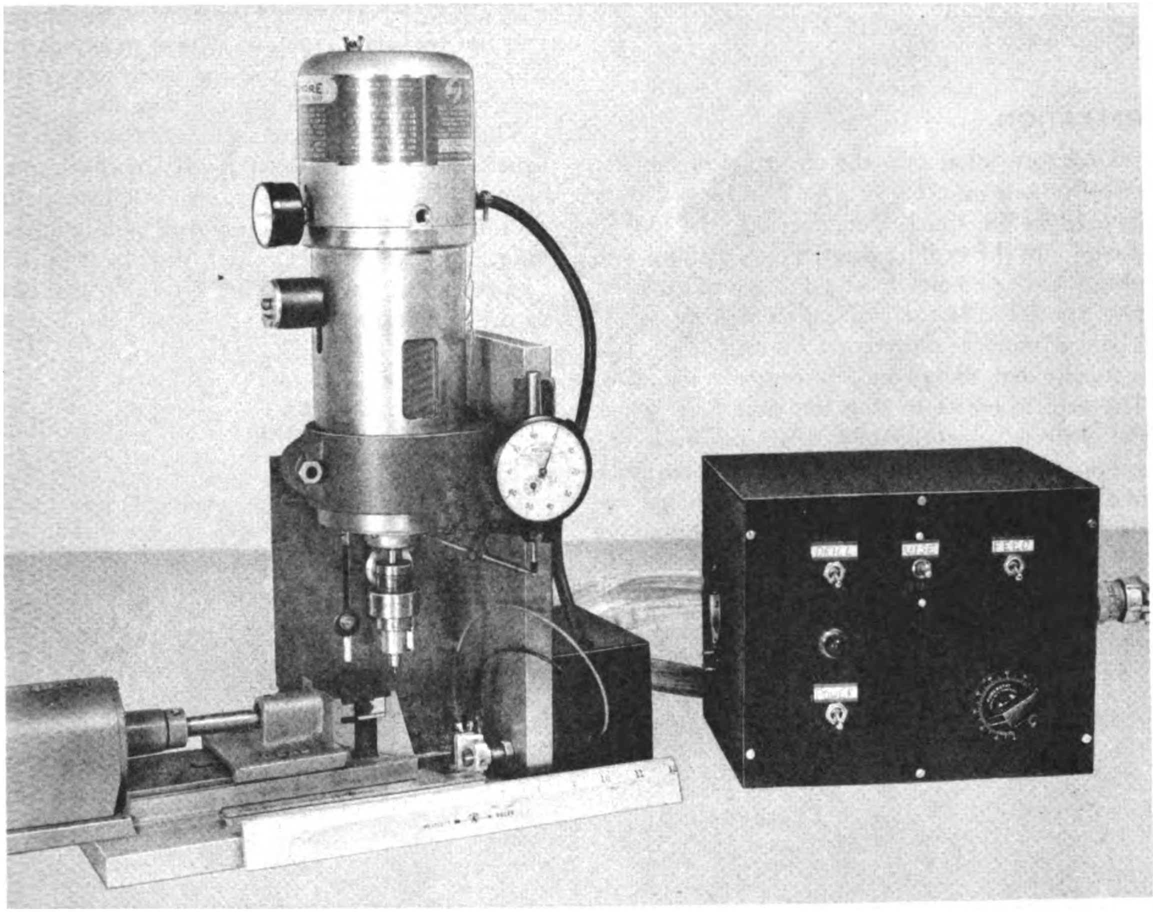
After completion of cutting, the vise is rotated to the loading position for subsequent sectioning operations and the lid is opened. A number of cuts may be made before the cooling water is removed from the box. The box is completely sealed during sectioning to prevent the spread of contamination. Air-borne contamination is controlled by the cell exhaust system, and solid contamination is removed by flushing.

Wheel changing is done by placing a socket on the end of the arbor wrench shaft and removing the arbor nut and integral flange. An open-end wrench is placed on the arbor shaft to prevent turning during removal of the nut. Wheels are removed and replaced with a manipulator.

REFERENCE DATA

Location: Hanford Atomic Products Operation.
Reference Drawings: SK-3-980, SK-3-6228.

REMOTE DRILLING DEVICE



Remote drilling device and control box before installation.

APPLICATION

This device drills defect holes as small as 0.005 in. diameter through the cladding of irradiated fuel rod specimens. Preparation of such surface defects in specimens is a necessary operation in the corrosion testing of irradiated fuel elements.

DESCRIPTION

The unit consists of a standard automatic drill head mounted vertically over a pneumatic vise. Special-purpose V-grip jaws on the vise automatically center the specimen in the drilling position. A cam, driven by a variable-speed motor and bearing on the drill head, controls the feed of the drill into the specimen.

A modified commercial quick-change chuck and drill holder facilitate the changing of drills remotely. The air vise is moved aside in steel ways, when changing drills, by a motor-driven lead screw. When returned to its original position with the specimen centered under the drill, the vise contacts a preset microswitch, stopping the drive motor.

All electrical wiring goes through insulating

plugs and a multiconductor cable to a control box located outside the cell.

A dial indicator indicates the depth of the drilled hole.

OPERATION

Drills are fitted into the special drill holders prior to their insertion in a cell. After a drill is secured in the quick-change chuck, the vise is driven into the drilling position. A manipulator places the specimen in the vise jaws, and the jaws are closed by the application of air pressure. The drill motor is started and the drill head automatically fed down until it contacts the cam. The cam is preset to stop the drill head when the drill is approximately 0.010 in. from the specimen. The operator then controls the feed of the drilling by adjustment of a variable resistor which controls the speed of the cam motor. When the desired depth of the drilled hole is reached, the drill motor is turned off. The drill head automatically returns to its upper position, clearing the specimen. The air vise is released and the specimen removed with a manipulator. The device is then ready for insertion of the next specimen, and the cycle is repeated.

When a drill becomes dull, the air vise is driven out. Lifting the slip ring of the quick-change chuck with a manipulator releases the drill holder. This is then removed by a manipulator, and a new drill and drill holder are snapped into position. After returning the vise to drilling position, the above cycle can be repeated.

REFERENCE DATA

Location: Westinghouse Atomic Power Division.

Reference Drawing: 60-A-9853.

REMOTE VERTICAL LATHE

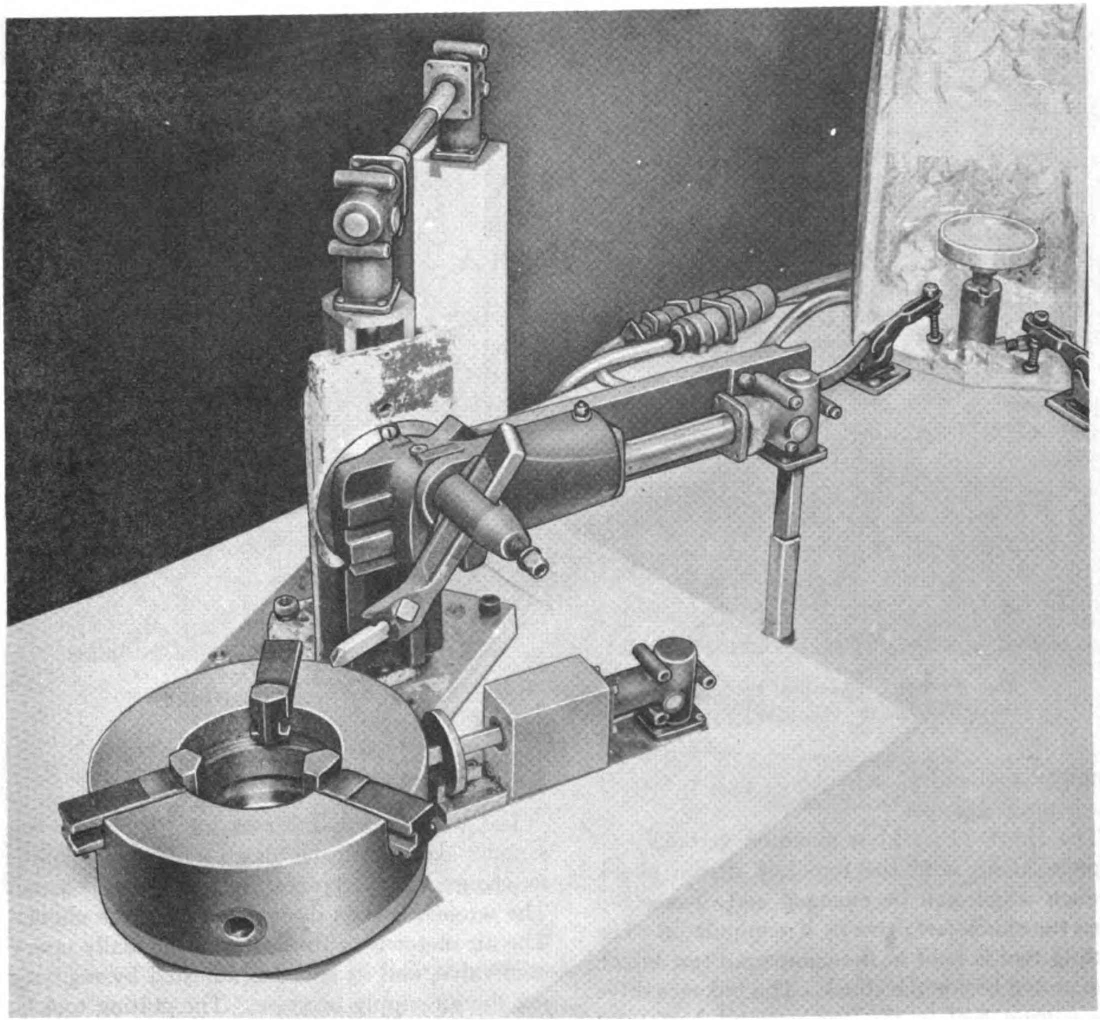


Fig. 1 Lathe assembly, top side. *A*, chuck; *B*, plate; *C*, chuck wrench; *D*, cutting tool; *E*, compound rest; *F* and *G*, linkages.

APPLICATION

Cutting and machining required for the disassembly of irradiation-sample capsules is performed on this lathe in a shielded cell. The maximum workpiece diameter that can be accommodated is 2¾ in. The maximum workpiece length is governed by the unobstructed distance above and below the chuck. The total vertical movement of the cutting tool is 3 in. Standard lathe turning tools are used and may be ground to any desired shape.

DESCRIPTION

The lathe consists of a chuck assembly, air-motor-drive assembly, belt-tension-control as-

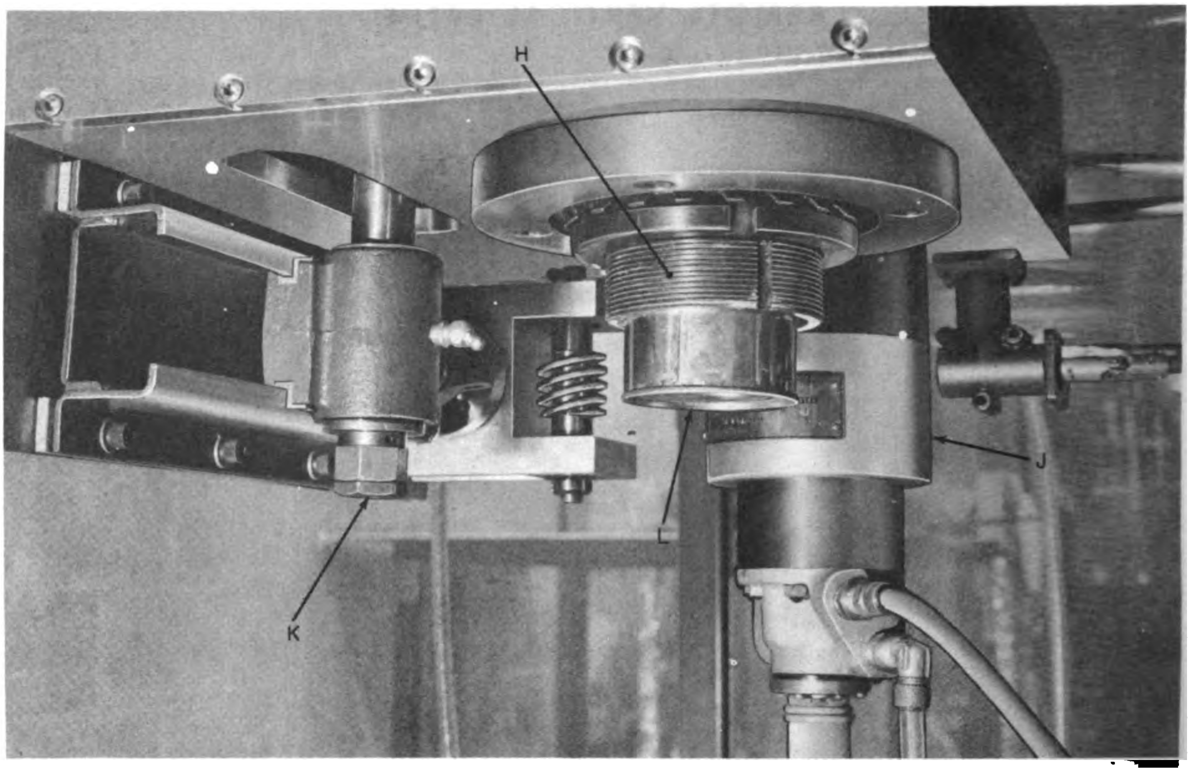


Fig. 2 Lathe assembly, lower side. *H*, chuck assembly; *J*, air motor; *K*, tension-control assembly; *L*, can.

sembly, toolholder assembly, and necessary mechanism linkages.

The chuck (Fig. 1) is mounted vertically on a plate along with the remotely driven chuck wrench which can be engaged and disengaged from the chuck-jaw drive by a manipulator. The cutting tool is held in the compound rest which is mounted beside the chuck. The linkages drive the cutting tool in the vertical and horizontal direction.

The lower section (Fig. 2) of the chuck assembly is driven by the air motor. The drive-belt tension is adjusted by the tension-control assembly. A can is placed in the chuck in order to collect chips that are generated in the cutting or in the turning operation. The control drives are operated by hand from outside the shielded cell.

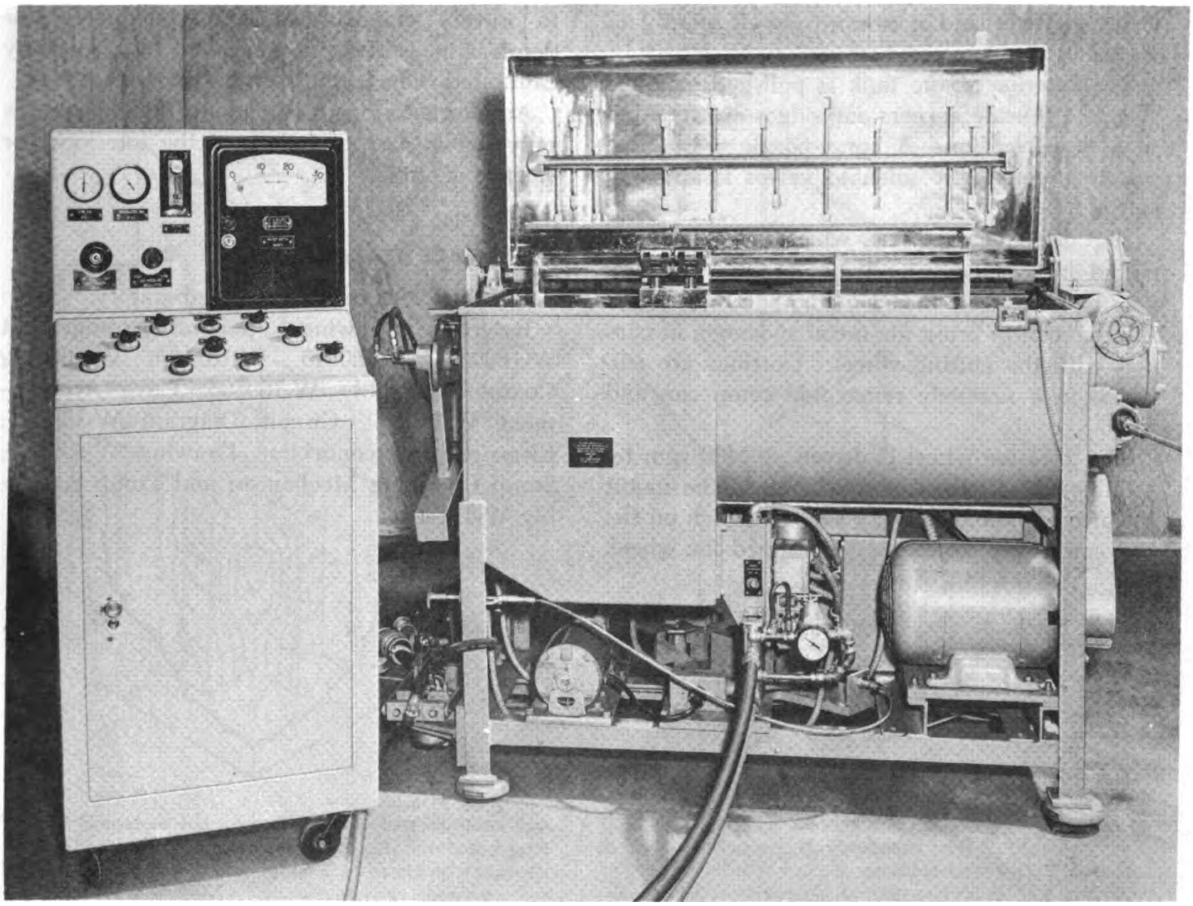
OPERATION

The workpiece is inserted into the chuck by a manipulator, and the chuck wrench is rotated to clamp the workpiece securely in the jaws. The wrench is then disengaged from the chuck. The air motor is controlled by a manually operated valve, and its speed is adjusted by regulating the air-supply pressure. The cutting tool is brought up to the workpiece by the manual-control drives before starting the machining operations. The workpiece is removed in the same manner as it was inserted, and the chip collection can is removed and emptied.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: KAPL T-7A8547.

UNDERWATER CUTOFF SAW



Saw and control console before installation.

APPLICATION

The underwater cutoff saw cuts off samples suitable for preparation as metallographic specimens from very highly radioactive metals. Specimens up to 2 in. in diameter and 36 in. long may be sectioned. The saw is operated inside a hot cell in conjunction with either electric-rectilinear or master-slave manipulation. The cutting is done entirely under water with an abrasive wheel. Other applications may be suggested by the low rate of wheel wear and the absence of specimen "burning" produced by this sectioning method.

DESCRIPTION

The machine measures 64 in. long by 33 in. wide by 45 in. high over all. Its approximate weight is 1500 lb. Connections to process water, high-level liquid drain, and off-gas exhaust are required. Three multiconductor cables and two instrument air lines connect the unit to a control console outside the cave. A manual handwheel operated through a plug in the face of the cell controls both the opening of the lid and the rotation of the vise. These operations are properly sequenced by an interlocking system of cams, microswitches, and electric clutches.

The control console measures 22 in. by 22 in. by 53 in. high and requires 110- and 220-volt a-c electric power and a compressed-air supply of 20 psi.

The interior of the tank is polished stainless steel. All inside corners and edges are rounded to a $\frac{3}{8}$-in. radius. A spray-nozzle washdown system operated by solenoid valves is attached to the lid.

The double-jawed vise, which is opened and closed hydraulically by water at line pressure, may be rotated by means of the handwheel outside the cell to bring the metal specimen in contact with the cutting wheel. Cuttings are collected in a remotely removable sump can and filter.

The abrasive wheel is driven at 2400 rpm by a 5-hp 220-volt three-phase motor. The motor is started automatically by a microswitch on the vise can as the vise is rotated toward the wheel. Maximum water depth in the tank is limited to a point 3 in. above the top edge of the wheel to prevent wheel breakage on startup. Water depth is measured and controlled by a specially calibrated differential pressure gauge.

An alternate means of opening the machine is provided in case of failure of the interlocks or electric controls.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawings: General Arrangement W-160064, W-160815, W-161436, W-160818; Console Assembly W-159895; Cave Arrangement W-160050; Circuit Diagram W-159887; Electrical Interconnection Drawing W-159888; Sump Changing Mechanism and Pump Assembly W-161432.

DISPOSABLE RADIOISOTOPE SHIPPING CONTAINERS

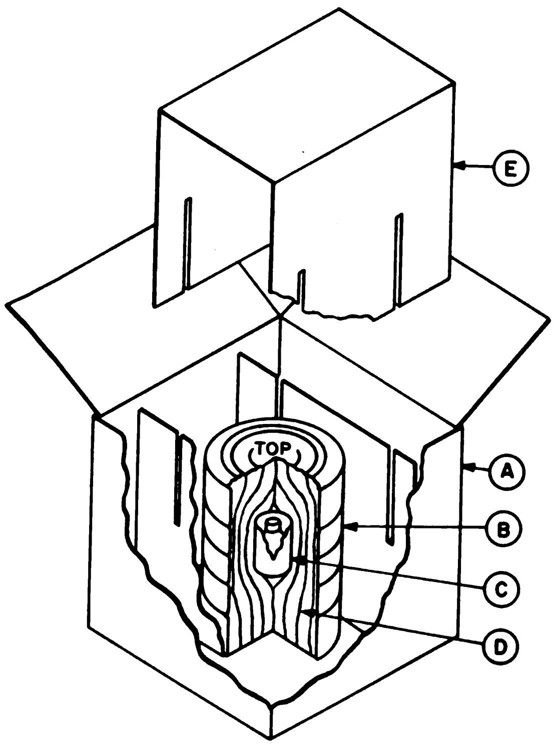


Fig. 1 Container for separated-liquid beta emitters and for small amounts of gamma emitters. *A*, fiberboard box; *B*, tin can; *C*, fiberboard tube; *D*, absorbent wadding; *E*, fiberboard insert.

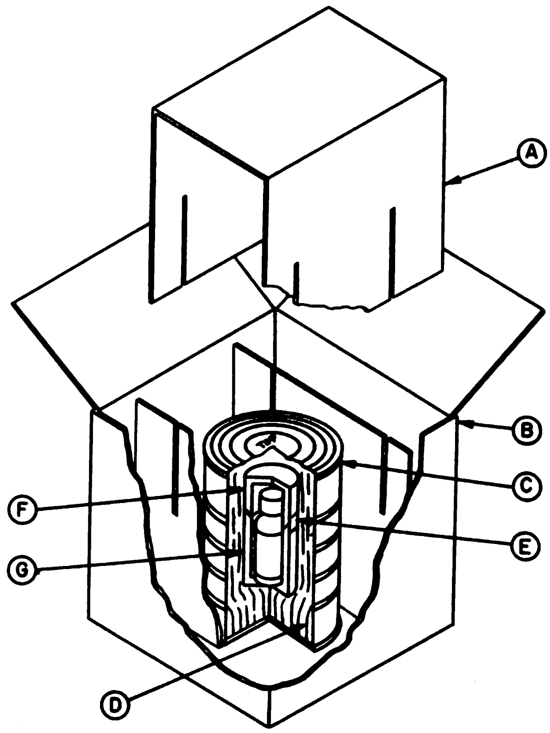


Fig. 2 Container for separated-liquid gamma emitters. *A*, fiberboard insert; *B*, fiberboard box; *C*, tin can; *D*, absorbent-paper wadding; *E*, masking-tape seal; *F*, top section of lead container; *G*, bottom section of lead container.

APPLICATION

Disposable containers are used for the shipment of liquid products, of solids irradiated and shipped in standard aluminum irradiation cans, and of gases. The use of these containers appreciably reduces the cost of shipping, decontamination, surveying, maintenance, and handling.

DESCRIPTION

The containers consist of tin cans and fiberboard cartons, with or without lead shielding.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Document: Radioisotope Containers Used by Oak Ridge National Laboratory.

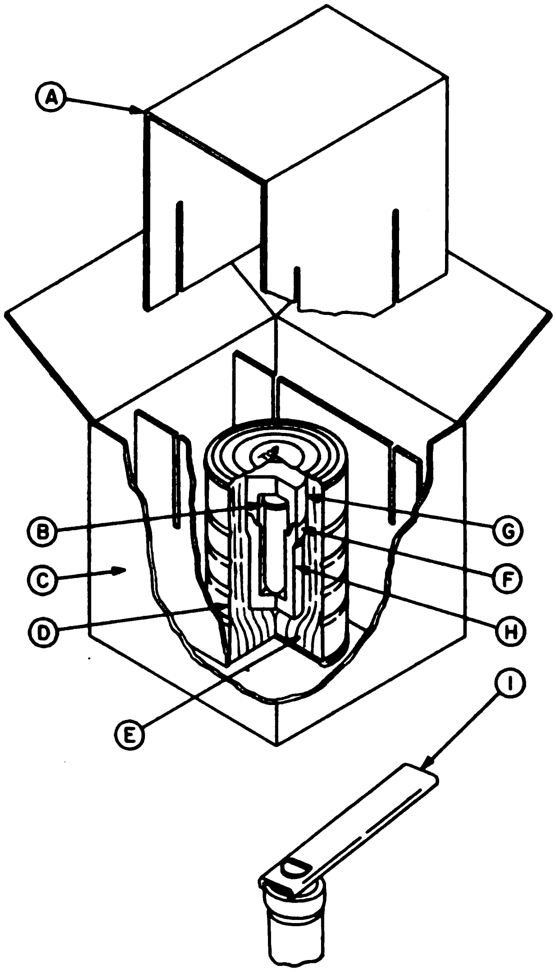


Fig. 3 Container for unseparated solids. *A*, fiberboard insert; *B*, aluminum can; *C*, fiberboard box; *D*, tin can; *E*, absorbent-paper wadding; *F*, masking-tape seal; *G*, top section of lead container; *H*, bottom section of lead container; *I*, decapper.

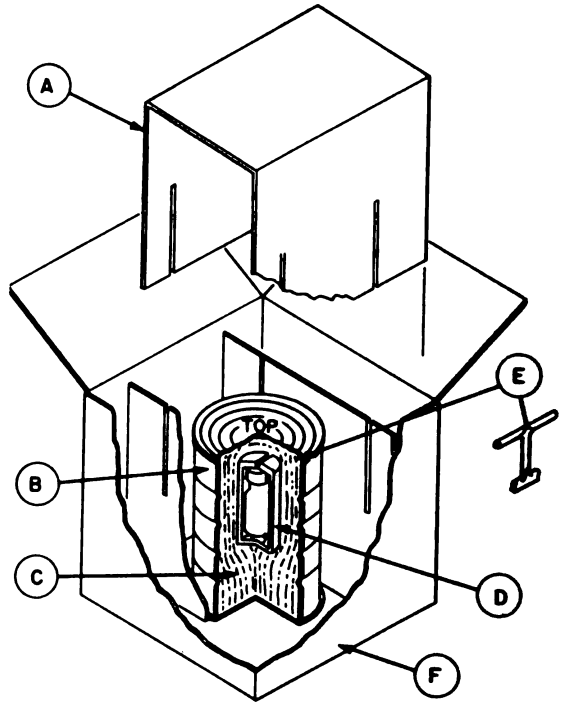


Fig. 4 Container for separated-liquid toxic beta emitters. *A*, fiberboard insert; *B*, tin can; *C*, cellulose wadding; *D*, stainless-steel cup; *E*, key; *F*, fiberboard box.

RETURNABLE RADIOISOTOPE SHIPPING CONTAINERS

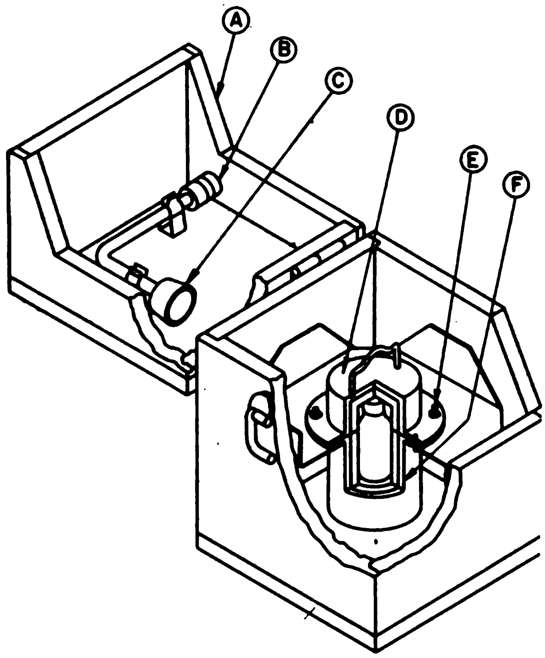


Fig. 1 Container for separated-liquid gamma emitters. *A*, ¾-in. plywood box; *B*, wrench; *C*, bottle-cap remover; *D*, top lead shield; *E*, nuts; *F*, bottom lead shield.

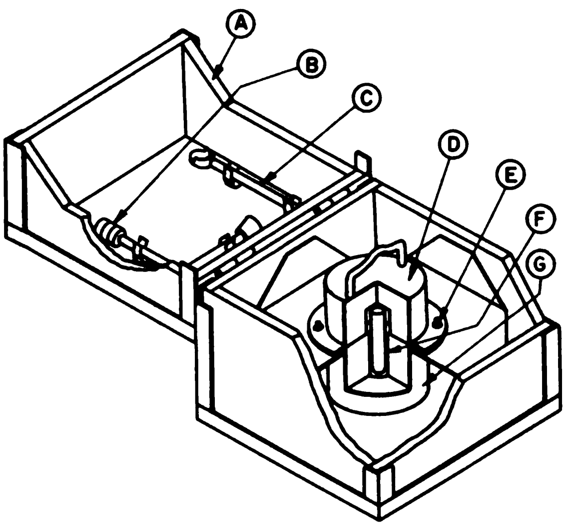


Fig. 2 Container for unseparated-solid beta and gamma emitters. *A*, ¾-in. plywood box; *B*, wrench; *C*, decapper; *D*, lead shield; *E*, nut; *F*, aluminum can; *G*, lead shield.

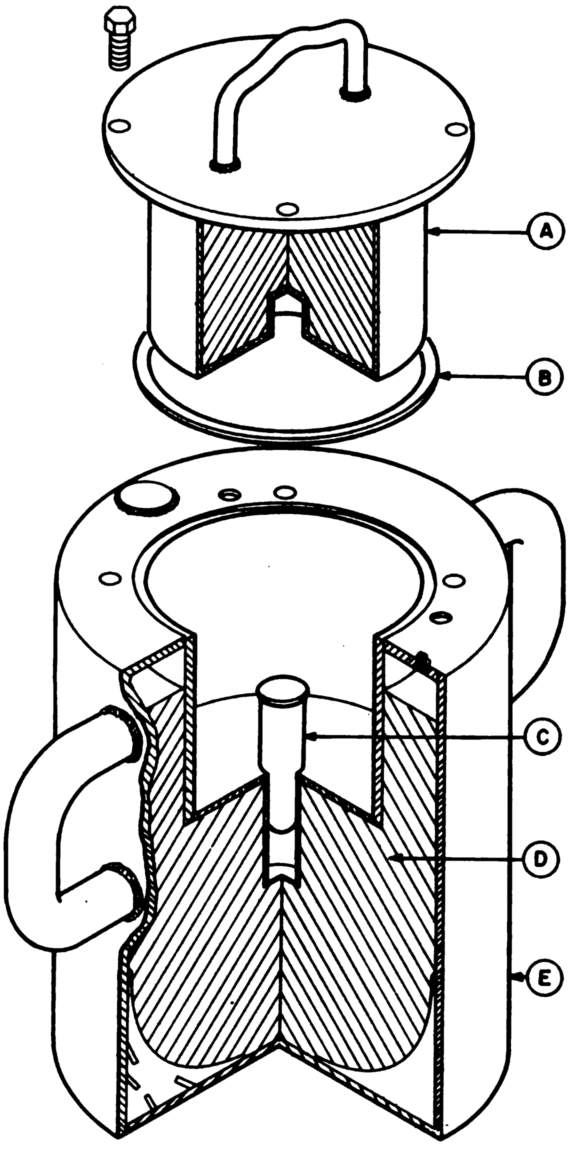


Fig. 3 Container for unseparated-solid gamma emitters. *A*, plug; *B*, neoprene gasket; *C*, aluminum can; *D*, lead; *E*, stainless-steel body.

APPLICATION

Returnable shipping containers are used for the shipment of liquid products, of solids irradiated and shipped in standard aluminum irradia-

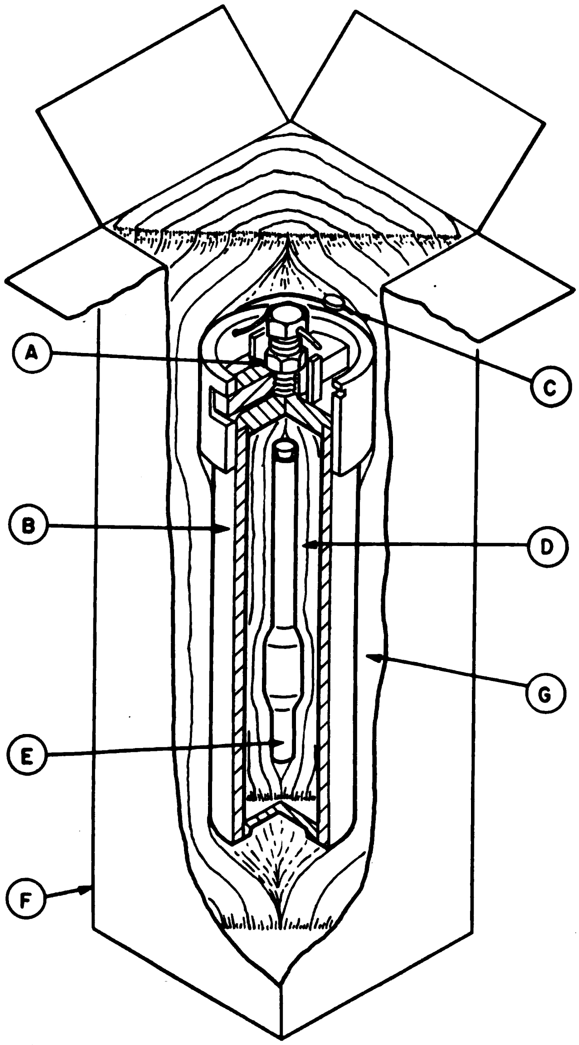


Fig. 4 Container for gases. *A*, locking bolt; *B*, aluminum container; *C*, wire and seal; *D*, paper wadding; *E*, Pyrex ampoule; *F*, fiberboard box; *G*, paper wadding.

tion cans, and of gases. The use of these containers appreciably reduces the cost of shipping, decontamination, surveying, maintenance, and handling.

DESCRIPTION

The containers consist of tin cans, fiberboard cartons, and lead shielding.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Document: Radioisotope Containers Used by Oak Ridge National Laboratory.

WASTE-DISPOSAL CASK

APPLICATION

This waste cask is used to transport waste cans containing solid high-level radioactive waste to a long-term storage area.

DESCRIPTION

The cask is a vertical shielded tube. The top is a shield plug, and the bottom is open. The hole in the bottom of the cask allows the waste container to be discharged into a storage hole after the cask is positioned over the storage hole. After discharging the waste can, the cask is removed and the storage hole in the floor plugged. The cask is then available for another transfer operation.

OPERATION

At some sites, there are available sets of vertical underground tubes set in concrete. These tubes have heavy plugs in the top. The function of these holes is to provide temporary storage for high-level waste until permanent disposal is accomplished.

Each storage hole is equipped with an aluminum liner or can with a chain running from the top of the liner to the bottom of the hole plug. When the waste is to be permanently disposed of, the liner is lifted out and shipped to a disposal area.

These aluminum liners are filled in the hot-laboratory cells as the solid waste is generated. When one is full, it is remotely lowered into the waste cask. The cask is used to transport or temporarily store the waste. The cask is emptied by placing it over a tube in the waste-storage area, pulling the pin in the bottom of the cask, and lowering the waste can by a chain running through the top of the waste cask. The chain is finally attached to the bottom of the storage-hole cover and the storage hole plugged.

In this manner a large volume of solid waste with a maximum diameter of 3¼ in. and a length of 36 in. can be handled without radiation exposure of personnel.

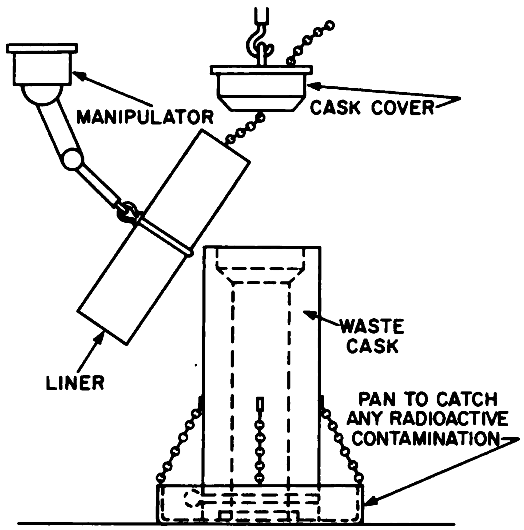


Fig. 1 Loading waste can into cask in hot-laboratory cell. 1. Waste can is filled with waste. 2. Waste can is hooked to chain running through waste-cask cover. 3. Cell hoist raises and lowers can into waste cask. 4. Waste cask is removed from radiation lock.

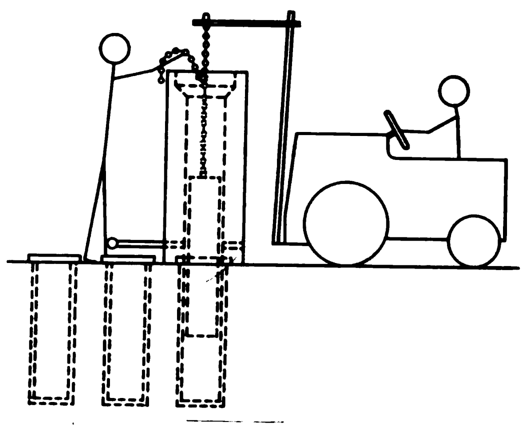
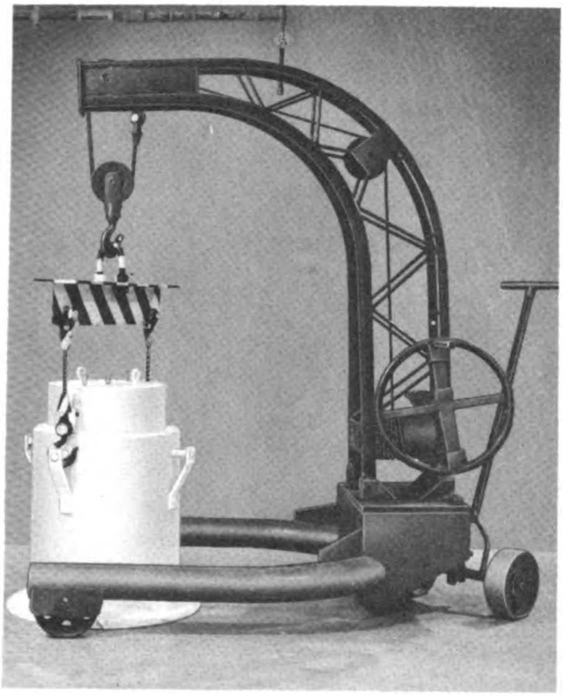


Fig. 2 Emptying waste cask at waste-storage area. 1. Fork truck lowers cask over empty waste tube. 2. Pin is pulled and waste can is lowered into tube. 3. Chain is attached to tube plug and tube is sealed.

REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: KAPL T-7A8904.

DISSOLVER SOLUTION CASK



Dissolver solution cask being hoisted for transfer.

APPLICATION

The dissolver solution cask is designed to store safely up to 500 ml of solution containing a total of 100 curies of fission-product gamma activity. While not considered suitable for long-distance shipment, the cask provides an inexpensive means of storing radioactive solutions and transferring them locally. Transfers of active solution into and out of the cask are made by displacement with a light organic solvent. Precise control of flow rate directly from the cask to process equipment is thus possible.

DESCRIPTION

The outer shell consists of a section of 20-in. mild-steel pipe welded to a circular base plate. The inner container is fabricated from stainless steel and measures 3½ in. ID by 6 in. high. The lead fill between the two containers provides approximately 8 in. of shielding. Three tubes lead to the inner container, labeled DIP, FILL, and VENT. The end of the fill tube extends 1 in. below the top of the inner container. The ends of the dip and vent tubes are at the bottom and top, respectively. Each tube is fitted with a stainless-steel diaphragm valve (see page 193) and a female stainless-steel ball joint for connection to external lines. The dip tube is so designed that holdup in the inner container is less than 1 ml.

The over-all dimensions of the cask are 26 in. diameter by 34 in. high. Total weight is 3200 lb. A removable two-piece lead-lined cap provides shielding for the valves while permitting access for maintenance. Lifting lugs are spaced around the outside at 90° intervals.

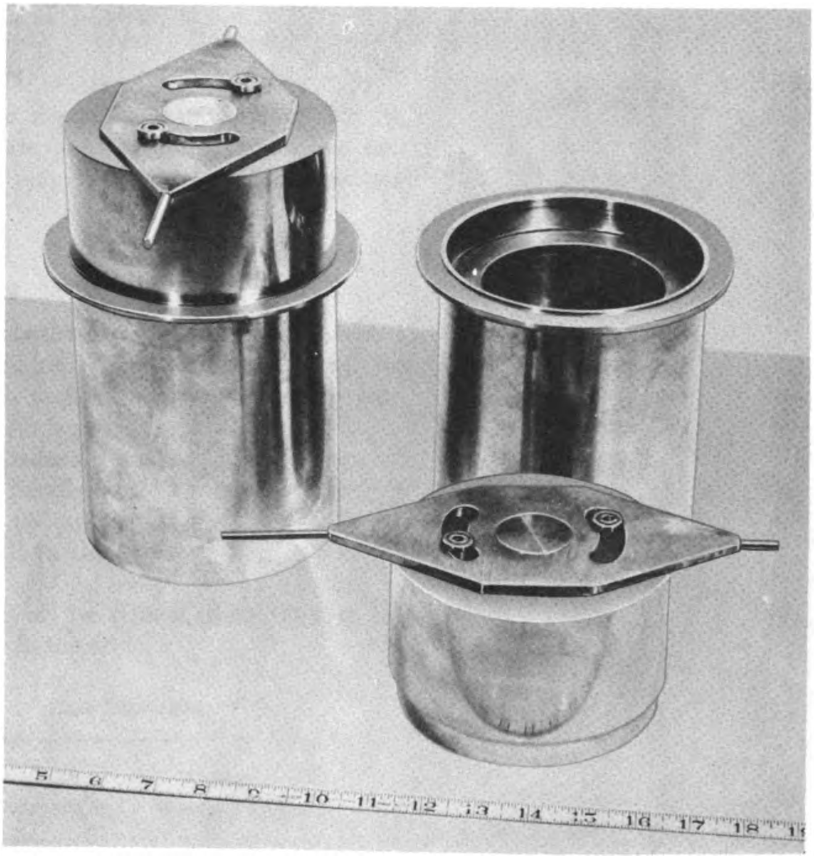
OPERATION

The cask is completely filled with a light organic displacement fluid before use. Radioactive solution is drawn into the cask by pulling the displacement fluid over through the vent line into a vacuum flask. Solution is transferred out of the cask by slowly pumping the solvent back into the inner container and displacing the radioactive solution out through the dip tube. The radioactive aqueous phase is always kept below the level of the fill line so that some solvent may be withdrawn or added separately, if desired, at any time.

REFERENCE DATA

Location: Savannah River Laboratory.
Reference Drawing: D-113270.

HOT-WASTE CONTAINER



Hot-waste containers with top locked on (left) and with top unlocked and removed from bottom section (right).

APPLICATION

This shielded waste container is designed to handle either dry or liquid waste. The cavity can hold either a 1-qt ice-cream carton for dry waste or a 16-oz bottle for liquid waste. The container may also be used to shield other radioactive material in storage.

DESCRIPTION

The hot-waste container is constructed of stainless steel and lined with 1 in. of lead. The overall dimensions are 5½ in. diameter by 10 in. long, and the cavity measures 3¾ in. diameter by 8 in. high. A locking device, easily operated by a manipulator, is provided to secure the top and bottom sections together.

OPERATION

Although the hot-waste container was produced specifically for use in junior caves, its design in no way hinders its use in other installations.

REFERENCE DATA

Location: Savannah River Laboratory.

Reference Drawing: Assembly and Details D-110364.

NESTING CASKS

APPLICATION

These three nesting casks, weighing 20, 90, and 450 lb, are used to store radioactive materials which may vary widely in size and activity level.

DESCRIPTION

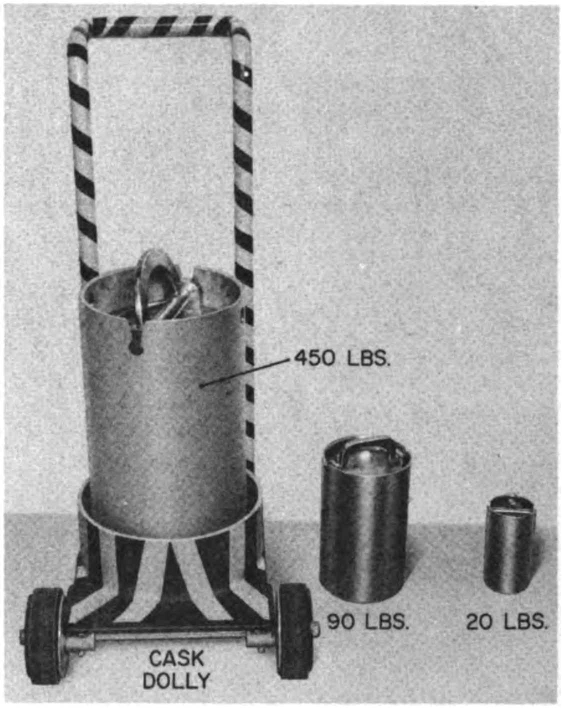
The casks consist of a steel outer shell with a poured-lead lining. Stainless steel is used for both the 20-lb and 90-lb casks; mild steel with an enamel finish is used for the 450-lb cask.

The casks feature a unique locking device on the lid. The handle may be rotated to either of two positions 90° apart. In one position the lid alone is lifted; in the other position the entire cask is lifted.

A summary of the critical dimensions of the casks is given in the table.

Cask Dimensions

Weight, lb	Over-all dimensions, in.		Cavity dimensions, in.		Lead shielding, in.
	Height	Diameter	Height	Diameter	
20	6¾	3½	3½	1⅜	1
90	10¼	6½	7½	3⅝	1
450	17	10¾	11½	6⅝	2



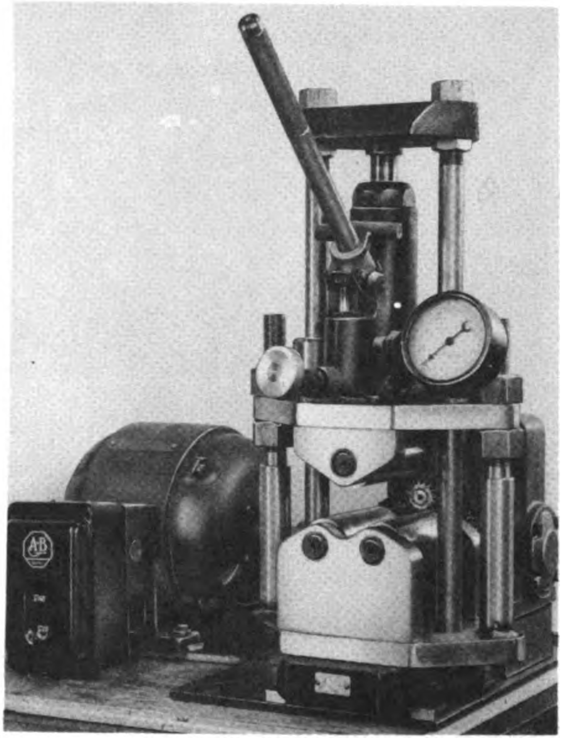
OPERATION

These casks may be used individually or in any combination, depending on the size and activity level of the material to be stored.

REFERENCE DATA

Location: Savannah River Laboratory.

JACKET-REMOVAL SYSTEM



APPLICATION

The jacket-removal system is useful in the remote removal of sealed cylindrical outer containers from their metallic enclosures. The apparatus is especially useful for removing the coverings from metals that have been sealed for irradiation in nuclear reactors. The apparatus can be used on all types of seals.

DESCRIPTION

The jacket-removal system consists of three rollers, a motor-and-gear assembly for driving the two lower rollers, a hydraulic jack and associated pressure indicator, and a movable plate for adjusting the spacing between the upper roller and the two lower rollers to accommodate sealed cylinders of various diameters.

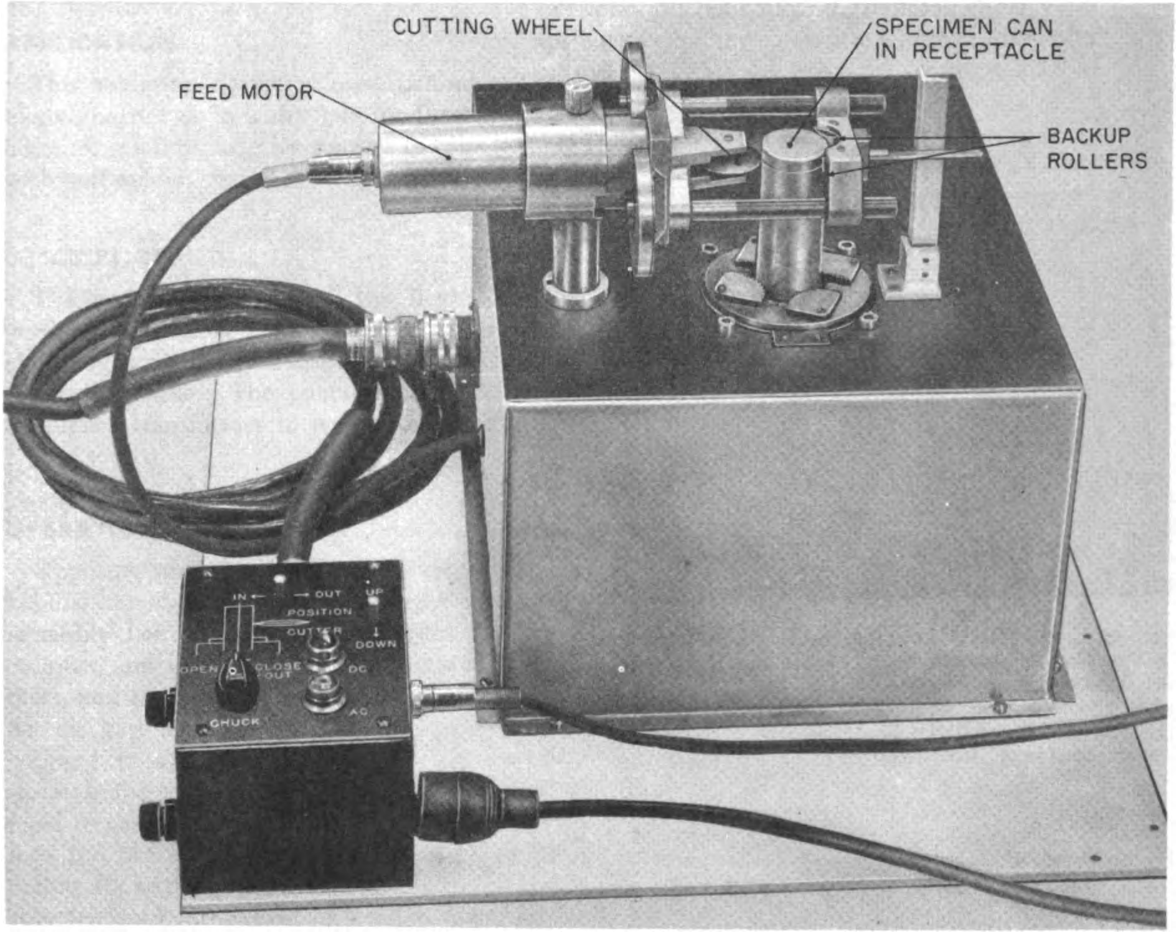
OPERATION

The cylinder from which the jacket is to be removed is placed on the two lower rollers, and the upper roller is brought into contact with the cylinder at a predetermined pressure. The lower rollers are rotated by the motor-and-gear assembly at a constant roller-surface velocity. Approximately 15 sec of rolling time will loosen the cylinder jacket and its end caps sufficiently to permit removal of the jacket. The rolling operation makes a clean fracture of the joints at which the end caps are attached and stretches the jacket so that the enclosed metal cylinder is easily removed from the jacket.

REFERENCE DATA

Location: Mound Laboratory.
Reference Drawing: 5-1091.

ROLLING-CUTTER CAN OPENER ANL MODEL 4



APPLICATION

This can opener accommodates welded cylindrical specimen containers ½ to 1½ in. in diameter and 4 to 8 in. long. The availability of suitable equipment for opening cans is an important factor in container design.

DESCRIPTION

The rolling-cutter can opener is a mechanized adaptation of the familiar plumber's pipe cutter. The larger enclosure contains a worm-gear reducer and motor to produce an output speed of 60 rpm. The hollow output shaft forms a receptacle for the specimen can. A set of friction-operated serrated jaws grips the can when the shaft rotates in one direction and retracts when the shaft rotates in the other direction.

A small d-c motor operates through gearing and fine lead screws to force the sharp-edged wheel into the can as the chuck revolves. The entire motor, cutter, and backup roller assembly is free to float in the horizontal plane and align itself with the can.

A second motor within the base enclosure raises or lowers the cutter assembly to the proper point on the can.

OPERATION

Since a pronounced burr is set up on the inside diameter, a suitable annular relief in the inner container must be provided opposite the proposed cutting position. Aluminum cans up to 0.050 in. thick are then parted in 10 to 20 sec.

REFERENCE DATA

Location: Argonne National Laboratory.
Reference Drawing: RCD-92.

SOURCE CAPSULE SOLDERING DEVICE

APPLICATION

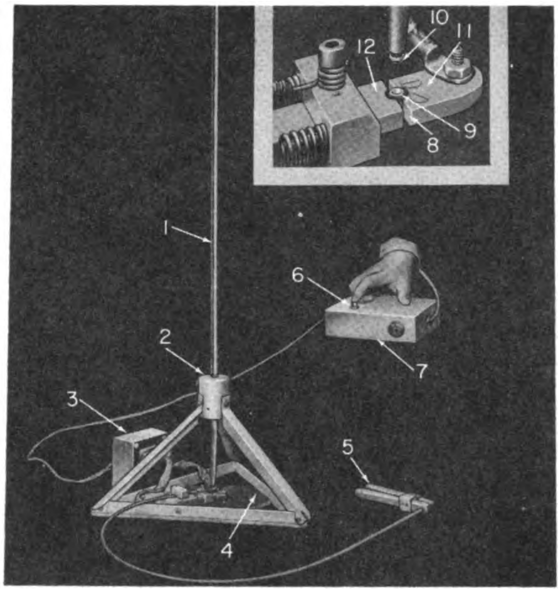
This soldering device is used behind a protective barrier or in a dry box for the encapsulation of small radioactive sources in cans sealed with soft solder.

DESCRIPTION

The main components of the device are a vertical holding rod, positioned over copper clamping contacts by a centering block, and a supporting base. The contacts are connected through a transformer to a remotely controlled power source.

OPERATION

Opposing surfaces of the capsule cup and cap are first tinned. (They may be threaded for screw assembly before tinning.) The split graphite cylinder and cup are placed between the contacts, and the movable contact is slowly closed. An air gap between the parallel faces of the copper contact bars concentrates all current through the graphite. The capsule cap is affixed to the tip of the holding rod and lowered into the centering block to a position several inches above the cup. The device is placed in a shielded enclosure where radioactive material is loaded into the cup. The cap is lowered and, with the power on, pressed or screwed into the cup. Current is applied until the solder is melted and seals the capsule. The contacts are then unclamped, and the capsule is removed by withdrawing the rod.



Source capsule soldering device. Inset shows cap centered over clamped cup before loading. 1, holding rod; 2, centering block; 3, current transformer; 4, base; 5, remote clamping contact; 6, remote push-button switch; 7, pilot light; 8, split graphite cylinder; 9, capsule cup; 10, capsule cup; 11, clamping contact (fixed); 12, clamping contact (movable).

REFERENCE DATA

Location: Los Alamos Scientific Laboratory.

REMOTE WASTE CANNER

APPLICATION

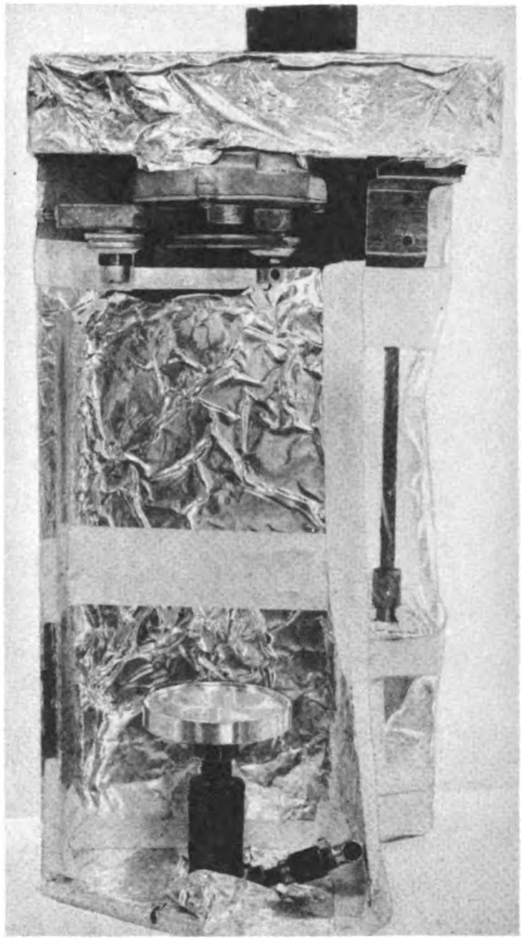
Difficult-to-handle high-level radioactive waste is sealed, and positive control is provided during handling or disposal when using the remotely operated canner.

DESCRIPTION

The apparatus consists of an automatic home canner modified by the addition of an electric motor for the drive and an air cylinder to raise the can against the sealing chuck.

OPERATION

The metal can is approximately 9 in. high by 3 in. in diameter. It is loaded with hot waste in the cell and then placed on a positioning plate on the canning apparatus. A cover is placed on the can, and the air cylinder raises it into the sealing position. An electric motor rotates the can while rollers roll over the top edge and make a seal. The can is then disposed of through standard hot-waste disposal procedures.



REFERENCE DATA

Location: Knolls Atomic Power Laboratory.
Reference Drawing: KAPL T-7A8512.

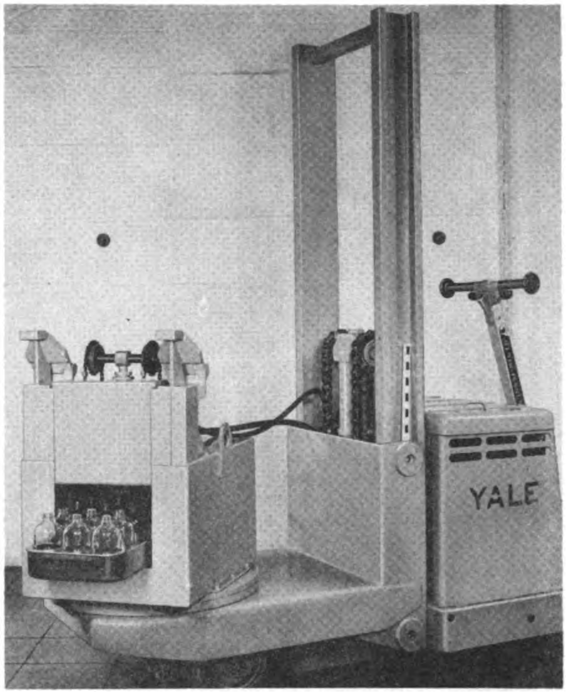
SHIELDED LIFT TRUCK

APPLICATION

This shielded lift truck is designed primarily to transport trays of bottles from a chemical hot cell, where the bottles are filled with radioisotope solutions, to a vault where they are stored. It could also be used to transport other radioactive objects up to 7½ by 11¾ by 15¾ in. in size.

DESCRIPTION

The shielded lift truck mounts a steel-framed lead box. The box is approximately 15½ in. high by 20¼ in. wide by 24¾ in. long and has inside dimensions of 7½ in. high by 11¾ in. wide by 15¾ in. deep. It has a hydraulically operated sliding lift door. The door-operating cylinder is connected to the existing hydraulic system of the lift truck. Door lift has limit switch control. A 1-in.-diameter hole in the back of the box permits entry of tongs used to pull in or push out the trays. The box is mounted on a turntable and thus may be swiveled manually in the horizontal plane.



Shielded lift truck with tray of bottles.

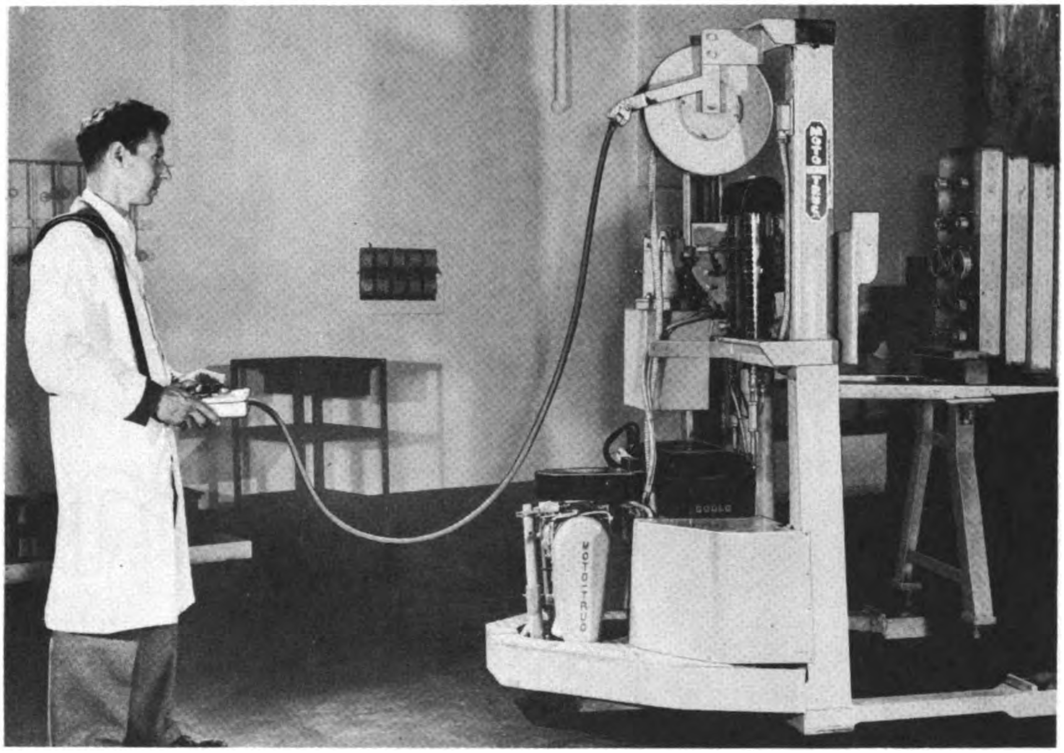
OPERATION

In operation the lift truck positions the steel-framed box at the hot-cell door with the aid of locating hooks on the box and mating pins on the cell-door frame. The cell door, a sliding-lift type, and the box door are opened. The tongs are then inserted through the hole in the back of the box and reach through the box to grasp the tray and pull it into the box. The cell and box doors are then closed, and the lift truck is driven to the unloading point.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawings: D-12466, D-12399.

REMOTELY OPERATED LIFT TRUCK



Demonstrating lift-truck operation.

APPLICATION

This electric-fork lift truck was originally modified for use in transporting completely set-up equipment racks to and from hot cells. Remote control of all operations permits the handling of contaminated cumbersome loads up to 4000 lb.

DESCRIPTION

The truck is 83 in. high, 49 in. wide, and has a maximum lift of 66 in. Power is supplied by a 330-amp-hr six-cell battery. Maximum speed under full load is 2½ mph. The standard manually operated steering tongue and handle are replaced by a separate motor and gear drive. The remote-control panel is attached to a metal shoulder harness and is connected to the truck by means of a 20-ft cable. The cable is wound on a truck-mounted cable reel and is provided with an automatic stop at its maximum extension. A brake on the truck is automatically applied by a spring whenever the control-panel key is locked. Breakage of the control cable also applies this brake. The electric circuits for travel, lift, and steering controls are also automatically interrupted if failure occurs.

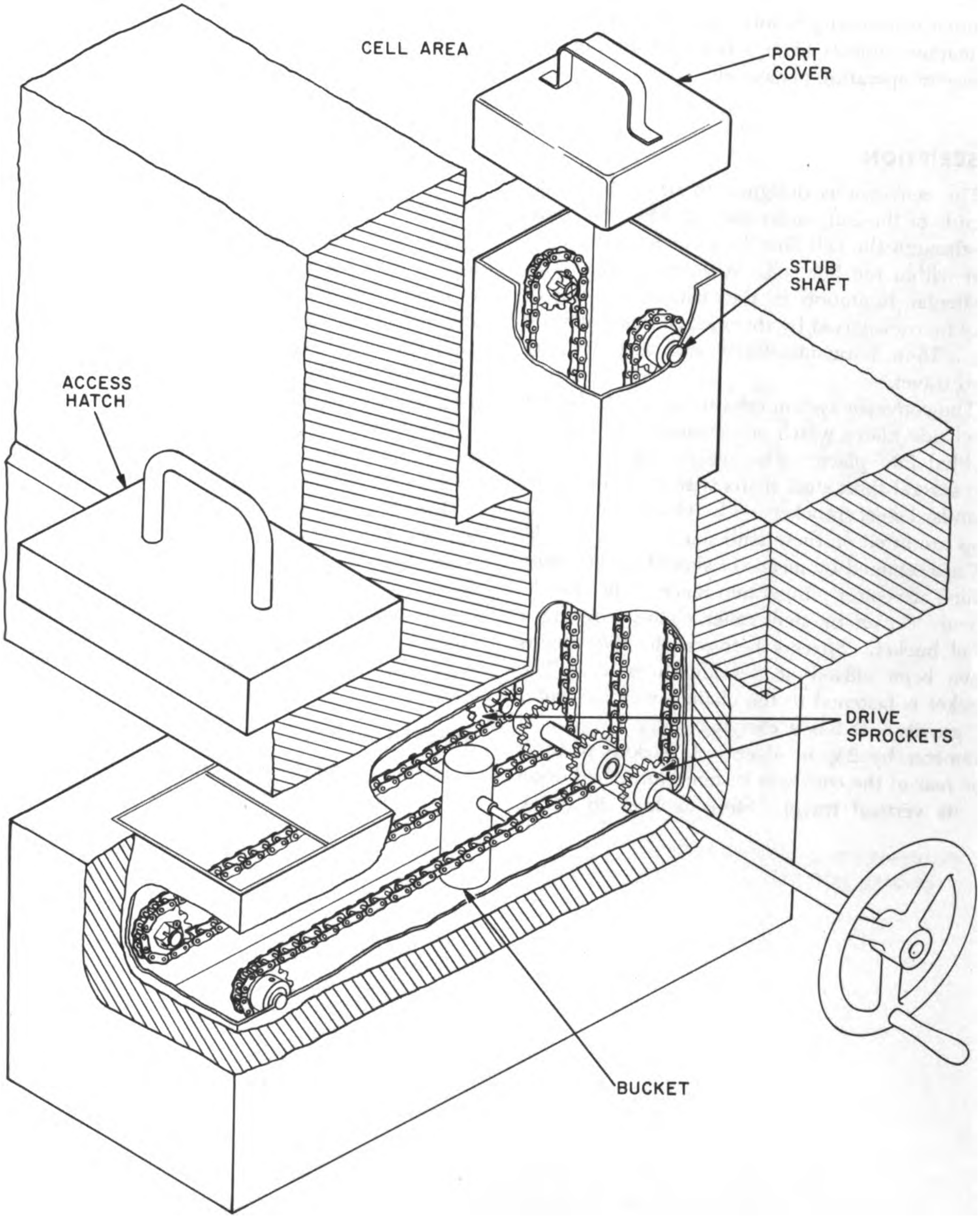
OPERATION

The operator wears the shoulder harness, permitting two-hand operation of the forward-reverse, steering, braking, and lifting controls. The operator can maneuver the truck easily while moving around freely at the end of the cable.

REFERENCE DATA

Location: Brookhaven National Laboratory.

CELL-ACCESS CONVEYOR



APPLICATION

The cell-access conveyor is intended for use where it is necessary to introduce or remove non-radioactive objects from a hot cell without exposure to operating personnel.

DESCRIPTION

The conveyor is designed to travel from the outside of the cell, under the cell floor, and then up through the cell floor to a convenient elevation within the hot cell. Although there is no particular limitation to the distance an object may be transported by this means, this conveyor has a 15-in. horizontal travel and an 18-in. vertical travel.

The conveyor system consists of two L-shaped steel side plates which are separated by spacers welded into place. Also welded to the plates are several short steel shafts with threaded ends. Standard steel sprockets with nylon journal bearings are fitted on these stub shafts. The sprockets are retained by means of slotted backup nuts which are cotter-pinned into place. The sprockets are driven by steel roller chains carrying a steel bucket. Spacers between the two chains have been affixed at periodic intervals. The bucket is fastened to the chain above its center of gravity. It has a carrying space $1\frac{11}{16}$ in. in diameter by $2\frac{3}{4}$ in. deep. A backup plate at the rear of the conveyor system limits the bucket in its vertical travel. Stops welded to the L plates limit the horizontal travel of the bucket. The conveyor is driven by a handwheel which is pinned to an extension shaft. With the exception of the nylon bearings, all parts are mild steel.

The entire conveyor system is encased in lead brick. A small hatchway has been provided in the lead for access to the bucket.

OPERATION

After the lead hatch has been removed, the desired object is placed in the conveyor bucket by hand. The hatch is replaced, and clockwise rotation of the handwheel causes the bucket to move into the cell. By proper location of the sprockets, the change in motion of the bucket from a horizontal to a vertical direction is accomplished automatically. Since stops limit the travel in either direction, the operator need only turn the handwheel until a stop is reached.

During normal operations, a cover is kept over the entrance port of the hot cell to prevent small contaminated objects from falling into the conveyor recesses. The cover is removed by a manipulator when it is desired to use the conveyor. This same manipulator serves to remove the transferred objects from the conveyor bucket.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawings: E-19630, D-19631.

EQUIPMENT-TRANSFER DRAWER

APPLICATION

The equipment-transfer drawer is used to transfer small equipment, paraphernalia, and reagents from a cold area into a hot area with a minimum exposure to personnel. The drawer is designed to provide adequate shielding in either its open or closed position.

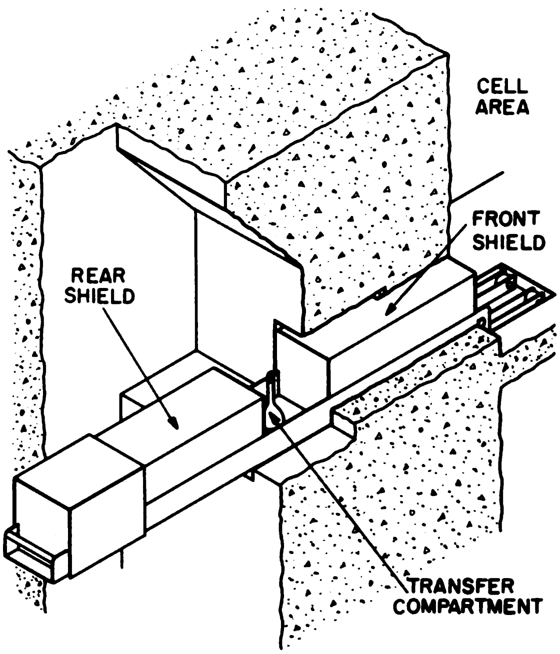
DESCRIPTION

The drawer is about 9 in. square by 6 ft long. It consists of three sections, the front and rear sections acting as shielding for the middle transfer compartment. The shielding is barytes concrete, with the remainder of the drawer consisting of a framework built up from standard steel structural shapes.

Two sets of rolls, each set containing four roller bearings, are provided in the floor of the hot cell. A bar stop, mounted on the rear shielding section, limits the forward motion of the drawer. A stepped port in the cell wall limits the return stroke of the drawer and provides guiding surfaces for the drawer.

OPERATION

A bar at the front of the drawer provides a suitable drawer pull. The drawer is hand-operated, with an estimated force of 10 lb necessary



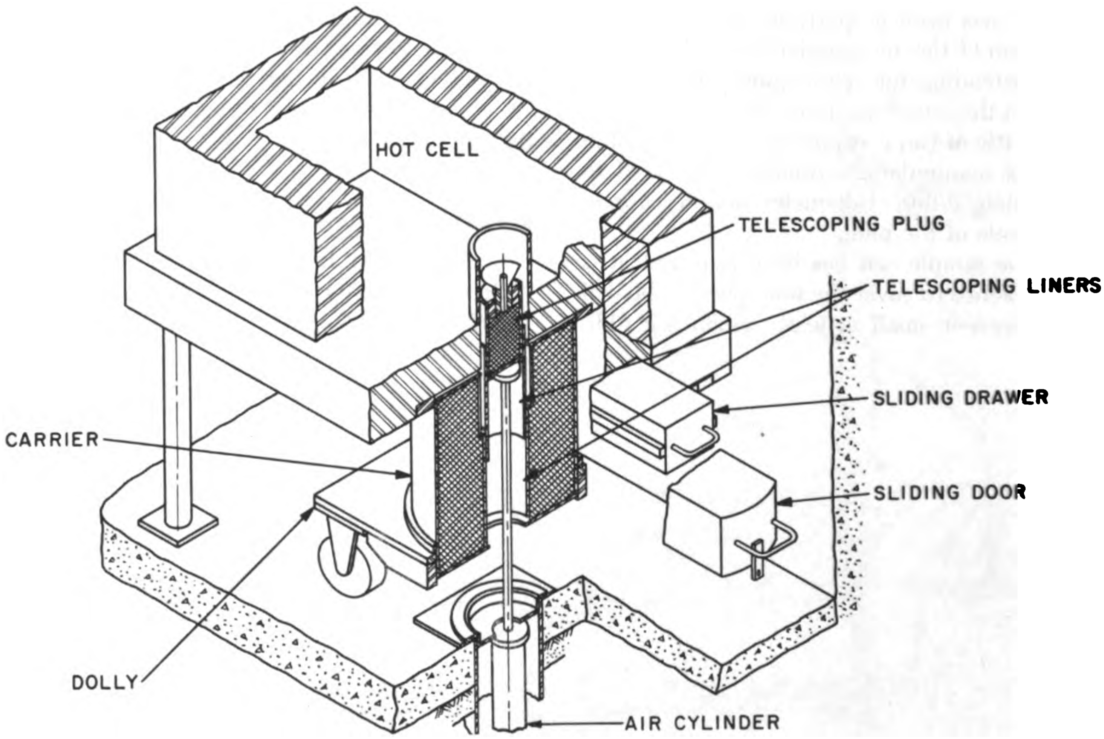
Schematic diagram of transfer drawer.

to initiate movement. A force of about 2 lb is required to maintain movement of the drawer.

REFERENCE DATA

Location: Oak Ridge National Laboratory.
Reference Drawings: D-18708, D-18709.

TELESCOPING CARRIER



APPLICATION

The telescoping carrier is designed to transfer radioactive materials in and out of a hot cell with a minimum of exposure to personnel. This is accomplished by means of a sliding drawer in the cell floor, a sliding door in the top of the carrier, and a telescoping plug in the carrier capable of moving along the vertical axis of the carrier.

DESCRIPTION

The telescoping carrier consists of four primary parts. These are the carrier body, a sliding door, a plug, and a set of two telescoping liners.

The carrier body is 18 in. in diameter by 9⅝ in. high and is, essentially, a stainless-steel lead-filled can.

The sliding door is a lead-filled stainless-steel block of rectangular cross section.

The plug is fashioned from a 4½-in. stainless-steel pipe. Both ends of the pipe are closed with end plates welded into place. The lower end plate works in conjunction with an air cylinder mounted in the floor under the appropriate cell. The plug is lead-filled. The lead acts as shielding and also serves as the base of the hole in the upper end plate. The hole has been provided to act as a seat for cans or bottles which may be placed in the carrier.

Two thin telescoping tubes are attached to the plug and to advance it up out of the carrier and into the cell.

OPERATION

The carrier is placed on a dolly and pushed into a recess under the cell floor. A horseshoe-shaped guide plate properly positions the carrier with respect to the cell. In this position, the ver-

tical axis of the carrier, the air cylinder mounted in the building finished floor, and a 6-in.-diameter pipe in the cell floor are all coincident.

The pipe in the cell floor is normally shielded by a sliding drawer. This drawer is opened after the carrier has been properly positioned.

Operation of the air cylinder raises the carrier plug by extending the telescoping tubes. With the plug in the raised position, the top of the hot sample bottle or can is exposed in the cell within grasp of a manipulator. Adapters are used to accommodate different-diameter sample cans in the 2-in. hole of the plug.

After the sample can has been removed, it is normal practice to cover the 6-in. pipe in the cell floor to prevent small articles, which are difficult to recover, from dropping into the carrier.

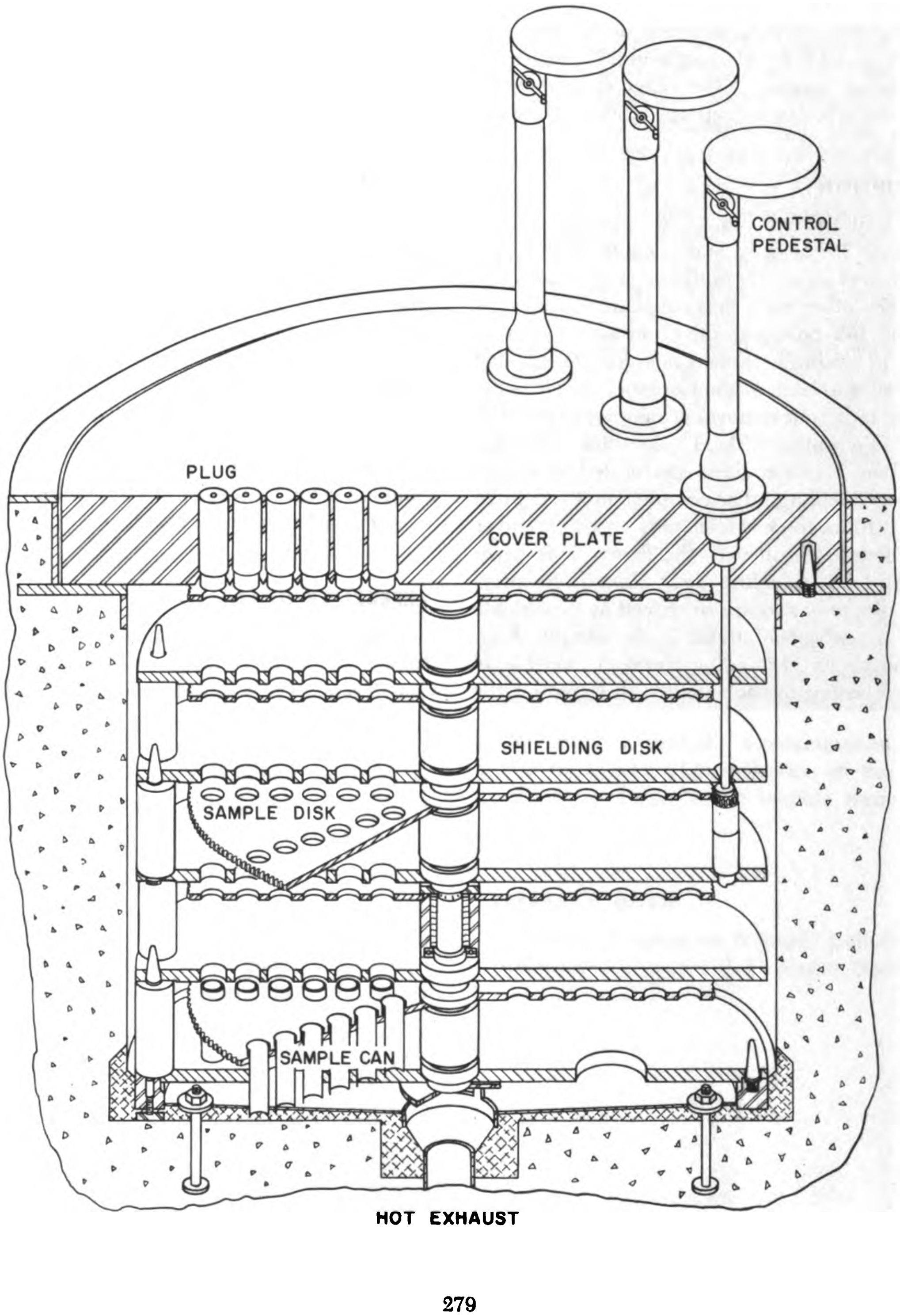
When operations have been completed, the carrier is used to remove the sample bottle to other areas for such additional processing as may be required. The carrier is withdrawn in the reverse order of its initial placement. The air cylinder is lowered and the plug falls into place, the sliding doors in the cell and the carrier are closed, and the carrier is brought out from under the cell on its dolly.

REFERENCE DATA

Location: Oak Ridge National Laboratory.

Reference Drawings: D-19005, D-19006, D-19059, D-12821.

DRY STORAGE UNIT



APPLICATION

This dry storage unit provides safe storage for a maximum of 786 irradiated canned samples. Five control pedestals mounted on the top permit the operator to select individual samples for insertion or removal. The other samples need not be disturbed or moved during this operation.

DESCRIPTION

The unit is sunk into a 76-in.-diameter concrete well 76 in. deep and consists of five perforated steel disks, 6 ft in diameter, mounted one above the other on a vertical shaft. Each disk contains 162 holes, arranged in six concentric circles, to retain the canned samples. One radial set of holes in each of the top four disks is made oversize to permit removal of samples in the disk below. Four other disks, 1½ in. thick, are sandwiched in between these perforated disks for radiation shielding. The complete unit is capped with a 10-in.-thick Meehanite cast-iron cover plate mounted flush with the floor. This cover plate and the shielding disks contain six oversized holes only and are so spaced as to coincide with the concentric circles in the sample disks. Control shafts, extending from a waist-level pedestal on top to each sample disk, permit the five disks to be individually rotated and positioned beneath the cover-plate holes. Steel plugs inserted in the cover-plate holes provide shielding when samples are not being removed.

An exhaust duct in the bottom of the well continually draws air down through the unit and ensures a safe flow of contaminated air.

OPERATION

To remove a sample from this unit, the disk containing the desired sample is first rotated until it lines up with one of the holes in the cover plate. The plug in the cover plate is then removed and a cask placed over the open hole. A rod with a claw on the end of it is then lowered through a hole in the cask, and the sample is gripped and withdrawn up into the cask. The cask is then raised, a steel plug placed in the open bottom of the cask, and the cover-plate plug replaced. Insertion of samples into the unit is made in a reverse manner.

REFERENCE DATA

Location: Hanford Atomic Products Operation.

Reference Drawings: H-3-5476, H-3-5478.

FLOOR-CONTAMINATION MONITOR (FIDO)

APPLICATION

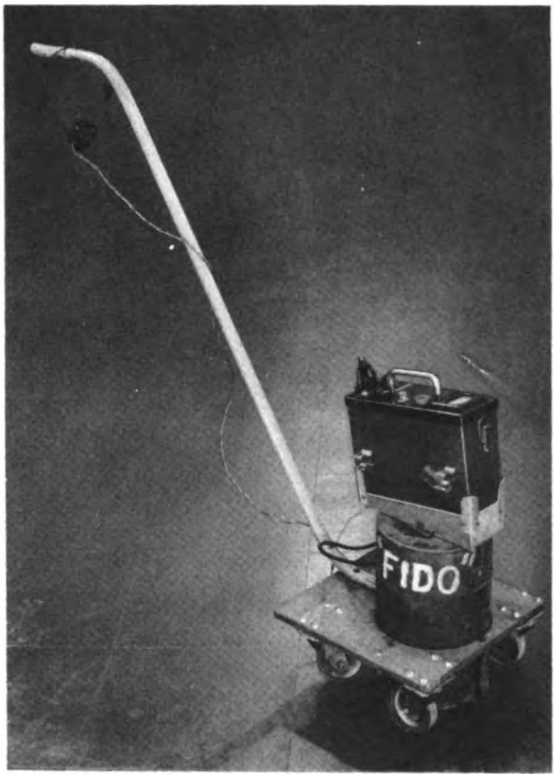
The portable floor-contamination monitor detects beta and gamma rays and is used for scanning floor areas before a radioactive smear survey. It is useful for the quick outlining of contaminated areas for isolation to prevent tracking and spreading of contamination and is a timesaver for locating hot spots. Side shielding permits its use in rooms with high background radiation. It is also useful for finding fixed contamination, such as contamination in cracks that would not be picked up by a smear survey, and may also be used to follow up on the decontamination process.

DESCRIPTION

The monitor is a commercial portable survey meter (Geiger-Müller) equipped with an end-window tube. The tube is mounted with the window down ¼ in. from the floor in the center of a 7-in.-diameter pig. Side shielding, 2¾ in. thick, prevents side radiations from giving false indications of contamination. The mounting block is set at an angle to facilitate meter reading, although in actual use the headphones prove more useful. The survey meter and shielding are mounted on a platform with casters, and a handle is provided to permit pushing the unit from a standing position.

OPERATION

The unit is pushed over the floor like a vacuum cleaner and requires no electrical connections as



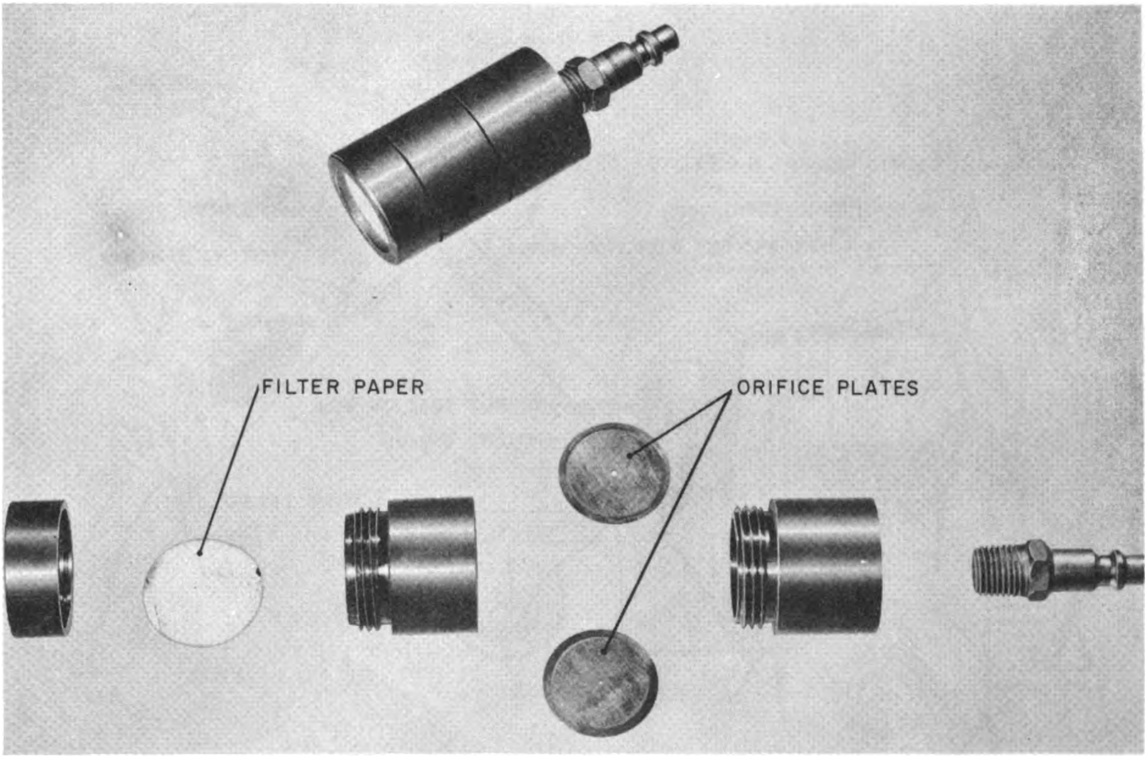
it is battery operated. Contamination is detected by a noticeable deflection of the survey meter or by pulses made audible through the earphones.

REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: J. C. Austin, *Nucleonics*, 13 (4), 56 (1955).

AIR SAMPLER



Air-sampler assembly and detail parts.

APPLICATION

This device is a convenient means for sampling air-borne radioactive contamination.

DESCRIPTION

The air sampler is approximately 3 by 1 in. It consists of a quick-disconnect fitting, a critical orifice plate, Whatman filter paper, and three threaded body sections. Two interchangeable critical orifice plates are provided for sampling either 250 ft^3 of air in 24 hr or 25 ft^3 of air in 30 min.

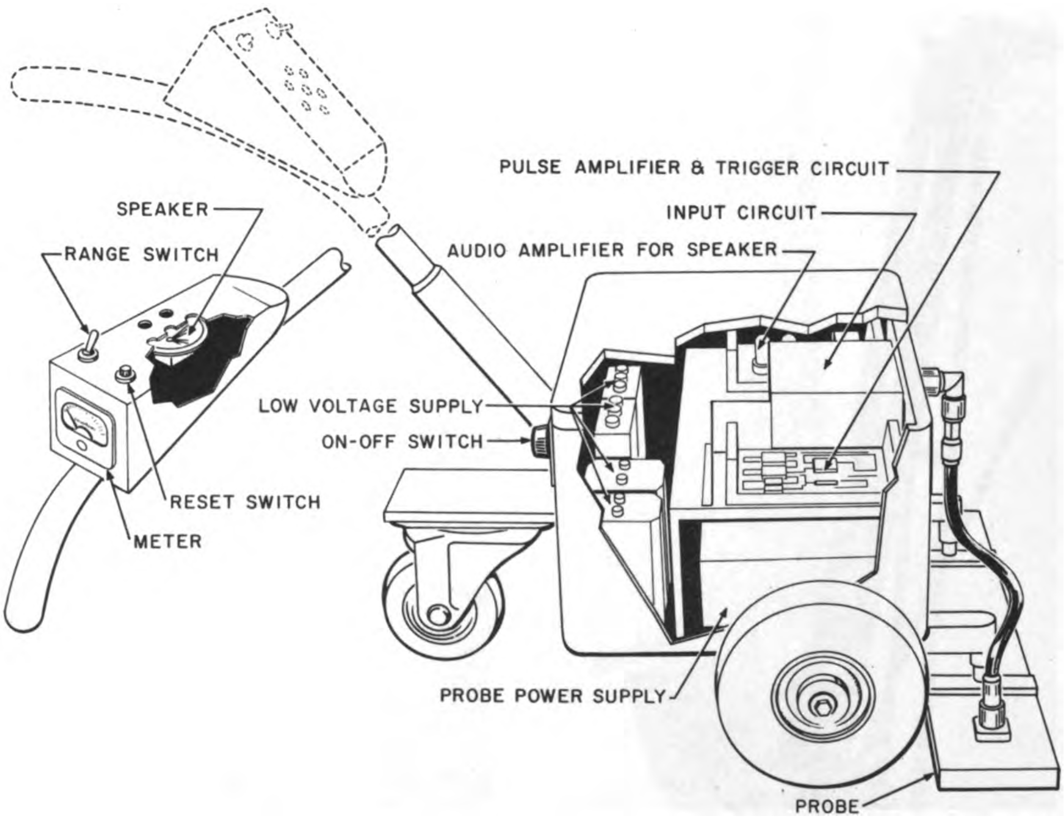
OPERATION

The unit is plugged into any outlet in the building vacuum system. The critical orifices hold the air flow constant for vacuum variations between 21 and 27 in. Hg.

REFERENCE DATA

Location: Brookhaven National Laboratory.

ALPHA FLOOR MONITOR



APPLICATION

This portable battery-operated instrument is designed to detect alpha contamination. Its use avoids the necessity of performing the tedious task of holding a small area probe at a fixed distance from the floor while searching for contaminated areas.

DESCRIPTION

The unit consists of a three-wheeled chassis mounting an alpha-sensitive probe and its associated power supplies and amplifiers. A 3-ft long handle supports the control box which contains a reset switch, a range switch providing ranges of 1 to 2000 or 1 to 20,000 counts/min, a loudspeaker for audible signals of alpha counts, and a counting-rate meter.

OPERATION

The instrument is pushed over the floor area to be monitored. The voltage to the probe is adjustable to allow for changes in atmospheric density at various altitudes. Alpha contamination is detected audibly or by reading the counting-rate meter.

REFERENCE DATA

Location: Los Alamos Scientific Laboratory.
Reference Document: LA-1713.
Reference Drawing: 26Y-70239.

SHIELD MOUNTS

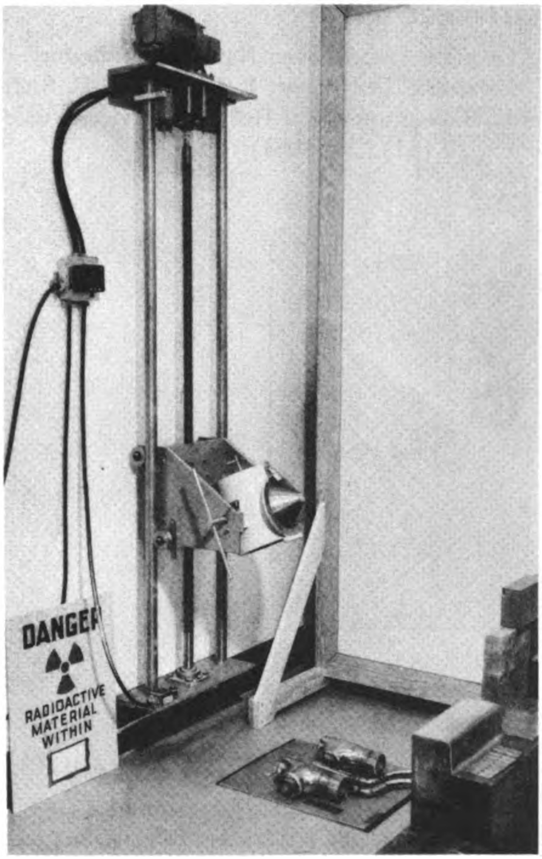


Fig. 1 Permanently installed wall shield mount.

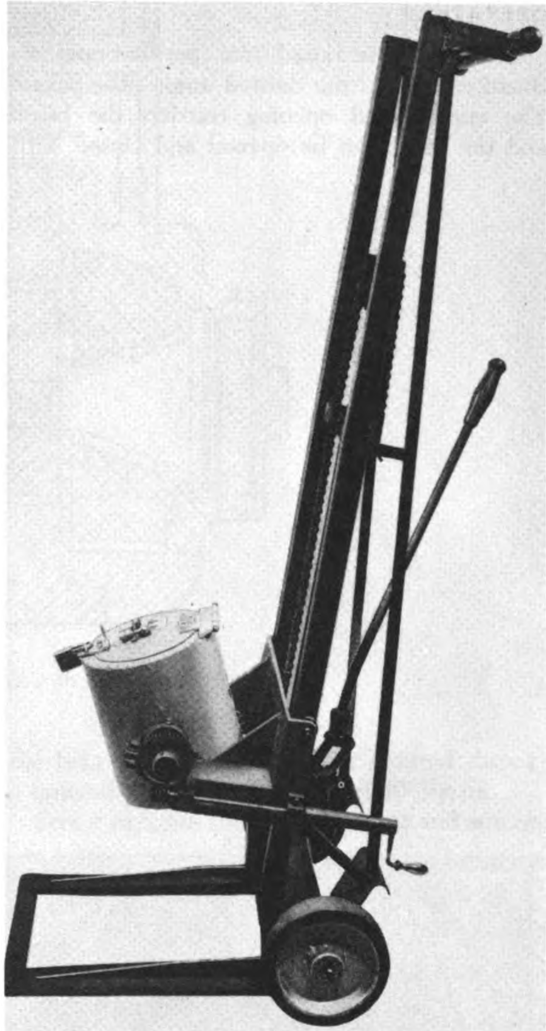


Fig. 2 Portable shield mount.

APPLICATION

Shield mounts are designed for supporting and orienting directional exposure shields containing gamma-ray sources used in radiography. By replacing the source shield with a collimating shielded counter, the equipment can be used wherever direction-sensitive counting is required.

DESCRIPTION

The wall shield mount (Fig. 1) is a permanent installation consisting of two vertical steel guide rails, an elevating screw, and a shield mount equipped with guide rollers. The screw is driven by a remotely controlled electric motor located above the guide rails. Limit switches at the top and bottom of the rails prevent overtravel of the mount. The mount is provided with a handle and setscrew for rotating the shield and locking it in position.

The portable shield mount (Fig. 2) is a commercial hydraulic hand-lift truck modified by replacing the standard platform with a special

mount for supporting the shield. The mount incorporates a hand crank and worm gear for rotating the shield.

OPERATION

The mount is raised into position and the shield rotated to the desired angle of exposure. The cone-shaped opening restricts the beam, and the cover can be opened and closed without exposing personnel to radiation. The beam can be collimated by withdrawing the source into a cylindrical hole at the apex of the cone.

REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: J. Austin and P. Richards, Radiography as a Hot Lab Service, *Nucleonics,* 12 (11), 78 (1954).

PORTABLE THULIUM X-RAY UNIT ANL MODEL 4

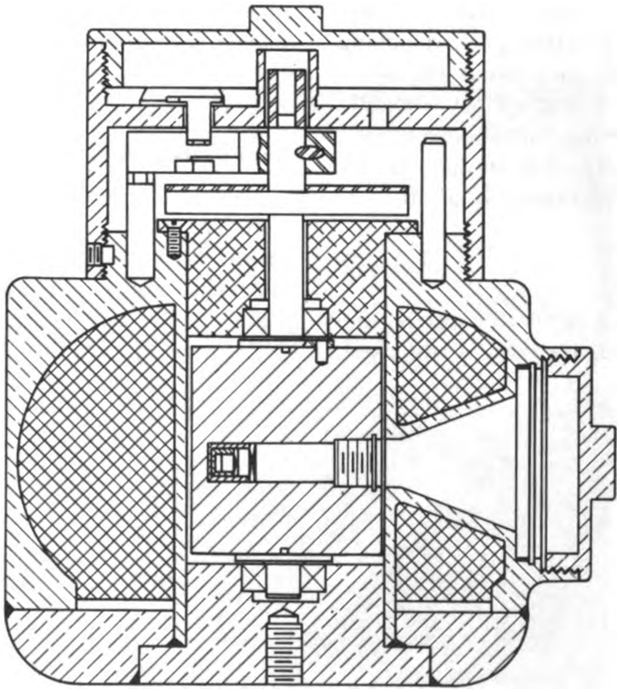


Fig. 1 Vertical section of x-ray unit with source in OFF position.

APPLICATION

This thulium x-ray unit, because of its small size and weight, portability, versatility, and economical construction, has many potential uses in industry and medicine.

DESCRIPTION

The source of x rays is 200 mg of radioactive thulium oxide pressed into an aluminum capsule. The thulium 170 decays with a 129-day half-life, emitting beta and gamma (x-ray) radiation with an energy of 50 to 100 kv. The capsule is recessed into a small cylinder of tungsten alloy which rotates 180° within an outer shield of lead-filled cast brass. In the OFF position, shielding reduces the radiation level to a maximum intensity of 20 mr/hr at the outer surfaces. The bulk of the shielding is required because of high-energy bremsstrahlung radiation produced by the beta rays. The x rays are emitted through a tapered port in a well-defined 40° beam.

Screw caps are used for shipment and storage.

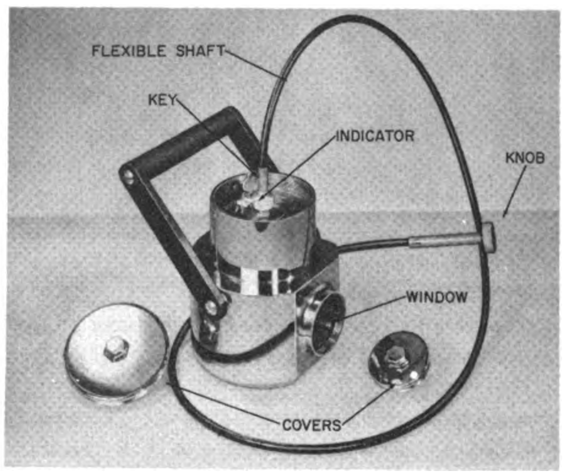


Fig. 2 Complete x-ray unit.

Visual indication of the position of the source is provided. The source is spring returned to the OFF position and held by means of a lock.

The source capsule is easily replaced by unscrewing the cap over the taper port, removing the Lucite window, and unscrewing the tungsten-alloy plug. The loading operation should be done with sufficient shielding.

The unit is approximately 6 in. in diameter by 7 in. long and weighs approximately 35 lb.

OPERATION

To operate the unit the caps are removed, the flexible shaft is attached, the key is unlocked, and the knob is rotated counterclockwise until the arrow points to the ON position. The unshielded source is then lined up with the tapered port and window. A radiograph of a hand placed 2 ft from the unit requires 20 to 30 sec exposure.

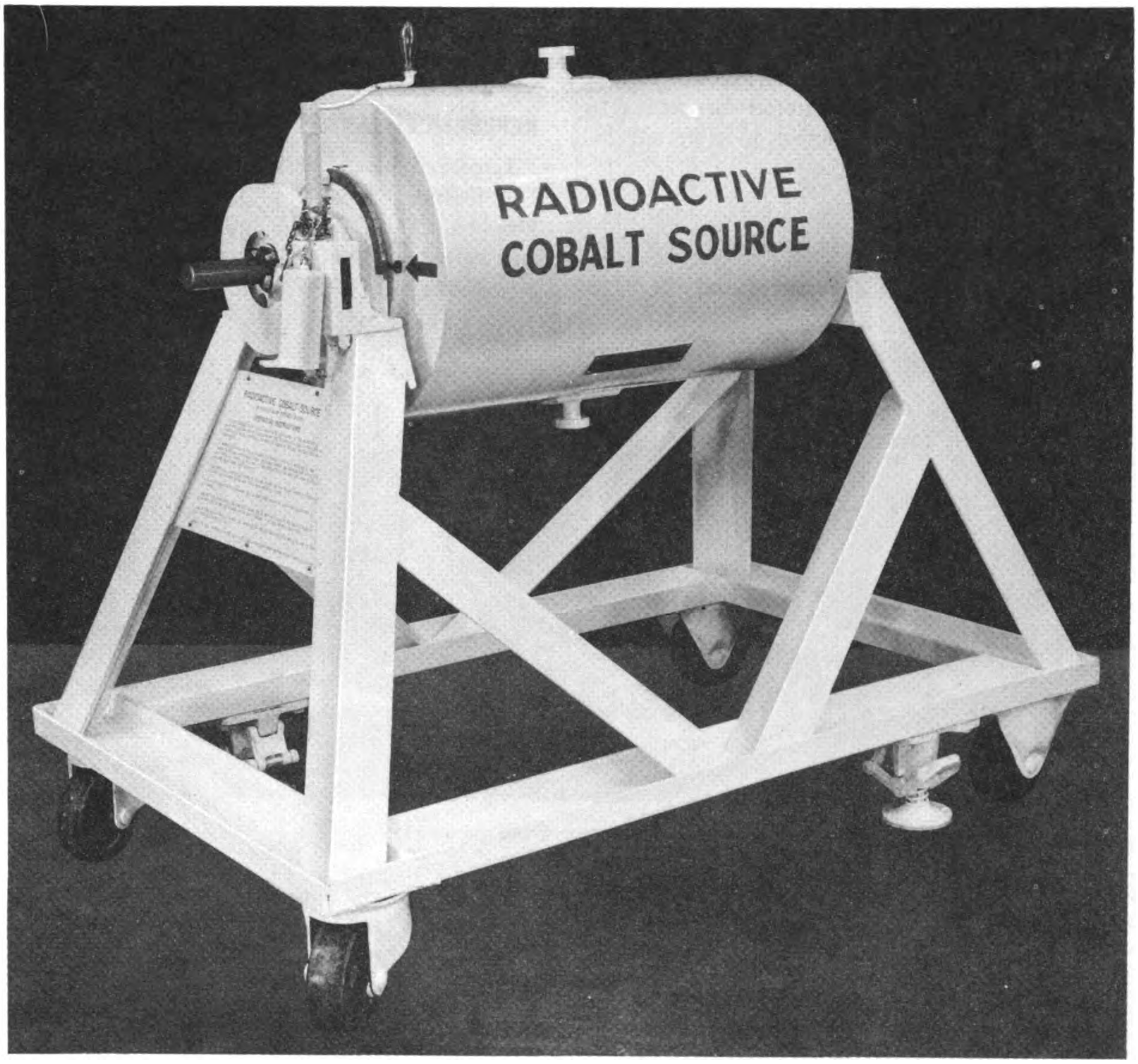
REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: S. Untermyer, F. H. Spedding, A. H. Danne, J. E. Powell, and R. J. Hasterlik: Portable Thulium X-ray Unit, *Nucleonics*, 12 (5), 35 (1954).

Reference Drawing: RCD-426.

PORTABLE COBALT 60 IRRADIATOR



APPLICATION

This portable irradiator was designed to accommodate up to 250 curies of cobalt 60 for use in medical research. It may be used to expose small objects or animals to high-intensity radiation or larger objects or animals to lower-intensity radiation. The field of radiation, which is moderately uniform, may be directed up or down or toward the sides by rotating the shield and source.

DESCRIPTION

The irradiator shield is a lead cylinder weighing 3500 lb and mounted with its axis horizontal approximately 3 ft from the floor. Trunnions at each end permit the shield to be rotated about its axis. The source is attached to one end of a rod which slides along the axis of the shield through the hollow trunnion. In the safe position the source is surrounded on all sides by at least 8 in. of lead. In use, the source rod is

pulled out until it hits a preset stop so positioned that the source is at the apex of a 45° cone which has been cut out of the shield. Although the shield may be rotated about its axis to any desired angle by means of a hand crank, a stop bolt is used to confine the shield rotation to one of four quadrants. Provision is made to lock the source in the safe position when not in use. The whole assembly is mounted on casters to permit the unit to be moved to different locations.

OPERATION

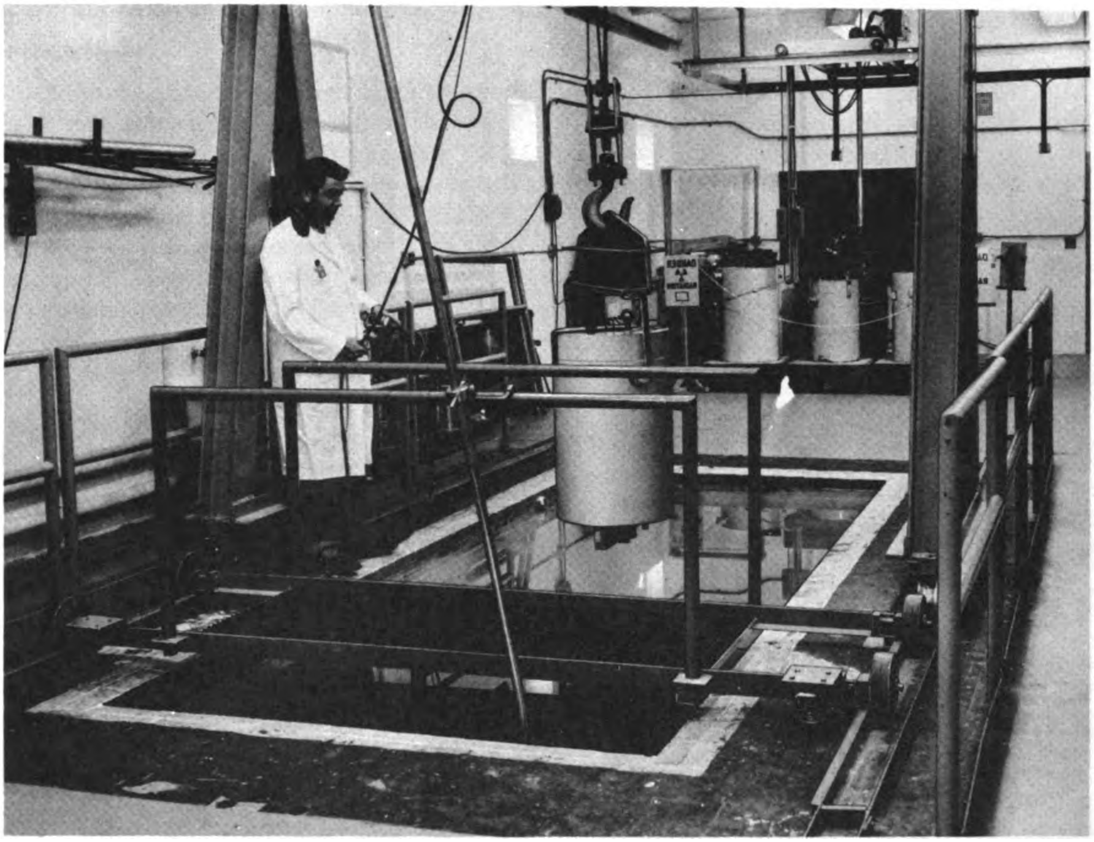
The unit is rolled into place, and the lead shield is rotated by the hand crank until the 45° cone is directed toward the target. To start the target exposure, the control rod is unlocked and pulled out until it hits the stop. To end the exposure, the rod is pushed in to the safe position.

REFERENCE DATA

Location: Brookhaven National Laboratory.

Reference Document: L. G. Stang, Jr., G. Strickland, A. C. Rand, and G. Selvin, Design and Performance of a Portable Irradiation Unit, *Nucleonics*, 12 (3), 62 (1954).

SHIELDING POOL



Lowering heavy container into pool.

APPLICATION

The shielding pool provides a convenient means for manipulating and storing sources as well as for carrying on irradiation studies under a transparent water shield.

DESCRIPTION

The shielding pool is 15 ft long, 6 ft wide, and 10 ft deep and holds 7000 gal of water. A well at one end is 14 ft deep, 4 ft long and runs the full width of the pool. A traveling crane, consisting of a 5-ton hoist supported by two A frames, rides on tracks laid parallel to the pool. A roller-mounted steel bridge can be positioned at any part of the pool. An ionization chamber suspended from the ceiling sounds a warning signal if radiation becomes excessive, when, for example, a source is brought too close to the water surface.

OPERATION

The hoist is used for lowering source holders into the pool. An operator standing on the bridge manipulates sources with the aid of long tongs. Binoculars can be used for close observations.

REFERENCE DATA

Location: Brookhaven National Laboratory.

DOUBLE-CAVITY IRRADIATION CHAMBER ANL MODEL 2

APPLICATION

Small specimens may be given large doses of gamma rays from a 400-curie cobalt 60 source in the double-cavity irradiation chamber (Fig. 1). The temperature in one cavity is closely controllable within the range of −30 to 130°C (Fig. 2). As the source is sufficiently shielded in all directions, it is possible to locate this unit in a laboratory without endangering nearby personnel.

DESCRIPTION

The double-cavity irradiation chamber is made up of two parts: a shield surrounding two cavities and a turret that houses the source. The turret is supported on hinges and swings from a position above one cavity to a position above the other. Constant temperature is maintained in one cavity by circulating a solution of ethylene glycol from a temperature-control unit through the annulus of a double-walled container. A fan circulates air about the specimens, while a thermocouple allows a constant check for deviations.

The cobalt 60 source is $\frac{5}{16}$ in. in diameter and 3 in. long. Total weight of the unit is 8000 lb.

OPERATION

From one to six specimens are positioned in a tray so that their center lines are 3 cm from the center line of the source. The tray is lowered into one of the cavities and the turret swung over it. A control rod, with the source fastened to its end, is lowered to start the irradiation. The samples rotate about their own axes as they revolve about the source to ensure uniform dosage. An interlock system prevents the turret from being moved while the source is lowered.

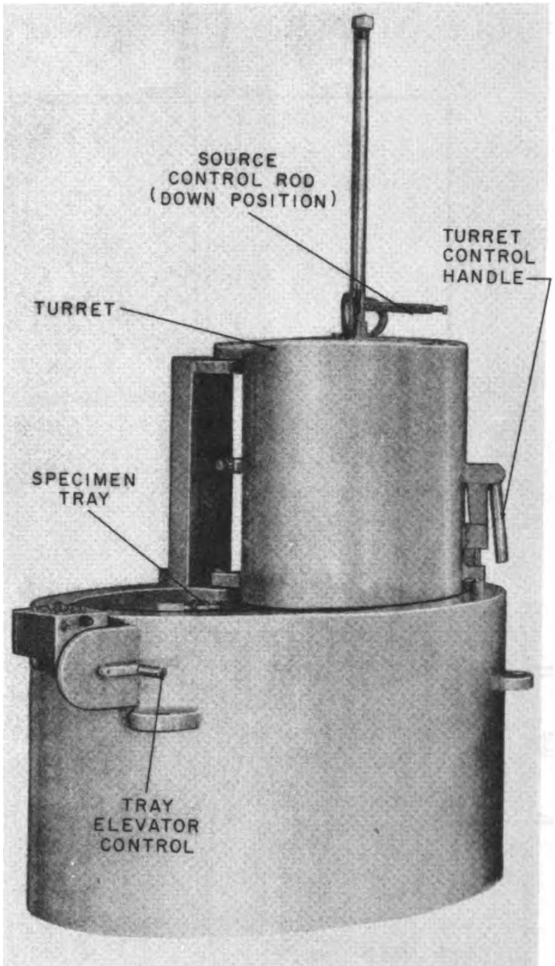


Fig. 1 Chamber for irradiating small samples.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Document: R. A. Blomgren, E. J. Hart, and L. S. Markheim, Radioactive Cobalt Laboratory for Chemical Research, *Rev. Sci. Inst.*, **24** (4), 298–303 (1953).

Reference Drawing: RCD-150.

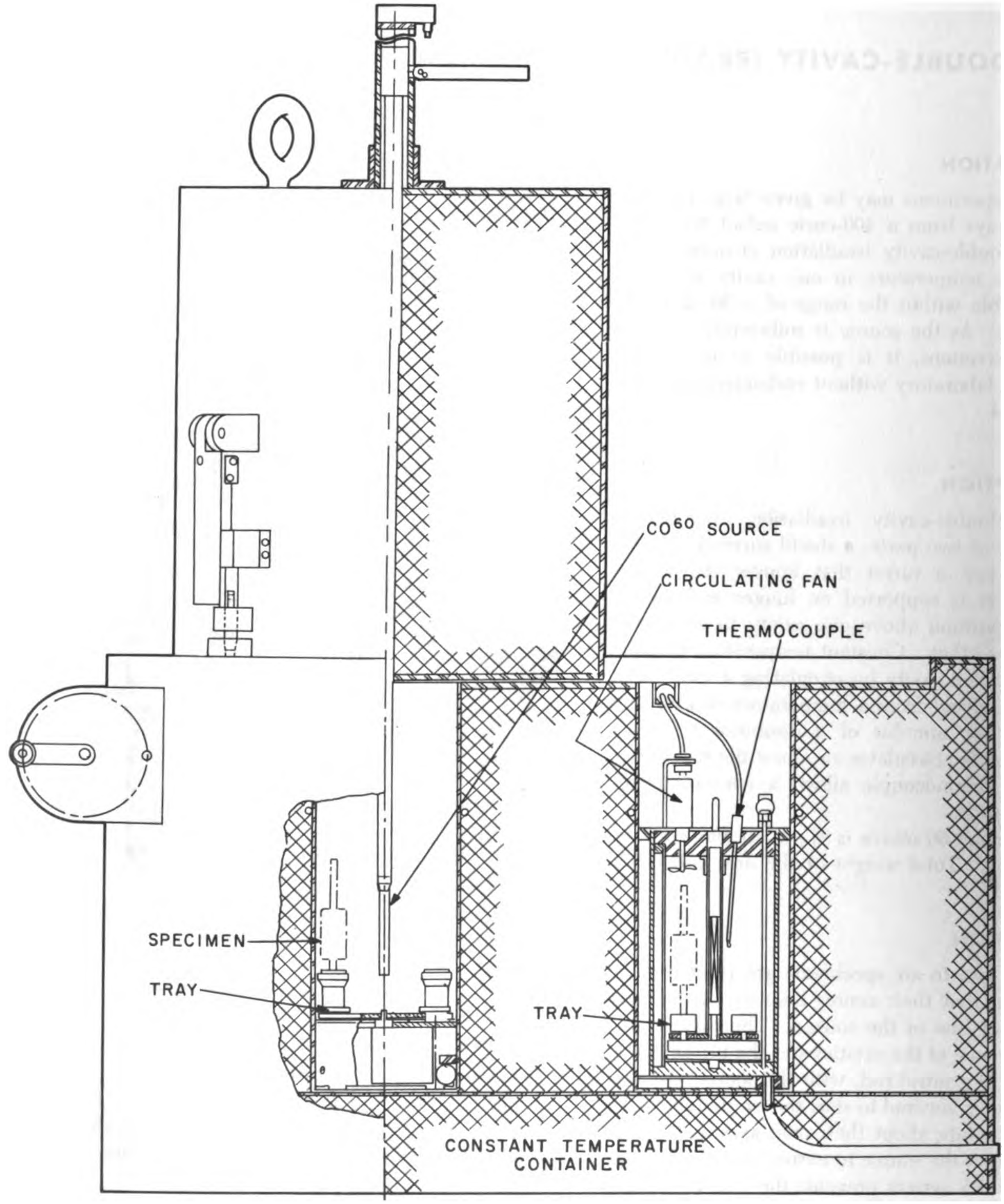


Fig. 2 **Schematic drawing showing method of controlling temperature.**

RADIATION CHAMBER ANL MODEL 5A

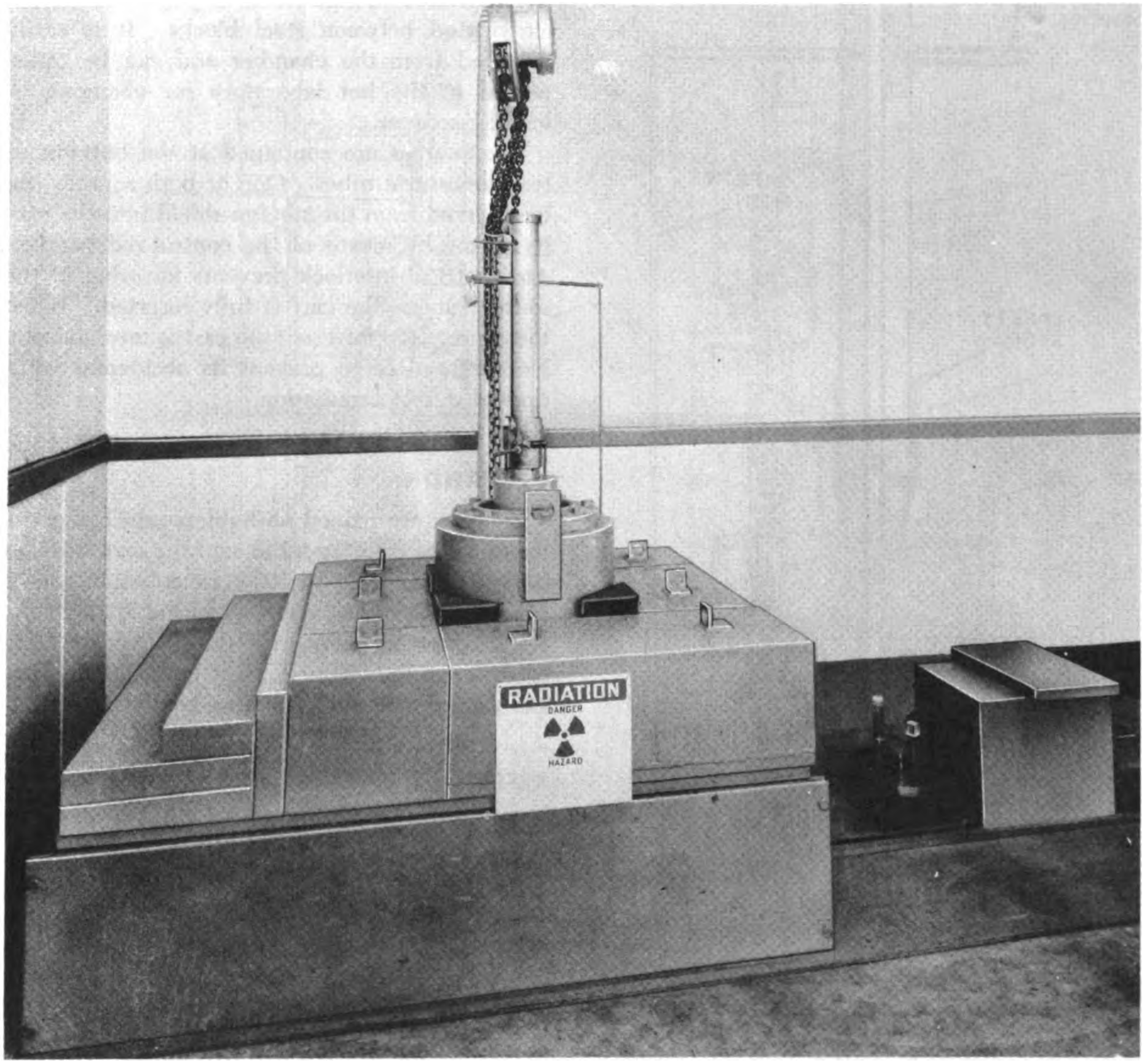


Fig. 1 Chamber for irradiating solid or liquid samples.

APPLICATION

This radiation chamber (Fig. 1) provides a means of irradiating solid or liquid samples with 20 or 100 curies of cobalt 60. Gamma and fission-product sources can be easily substituted for the cobalt to provide a complete array of sources. An irradiation cavity 10 by 20 by 12 in. high allows various sample sizes and source distances.

DESCRIPTION

The lower section of the chamber is constructed of steel plates around three sides of the rectangular cavity. The cavity (Fig. 2) is shielded on the remaining side by a rolling cart. The cart carries a tray, motorized sample table, and centering cone for positive source-to-sample location. Utilities, such as gas, electricity, and

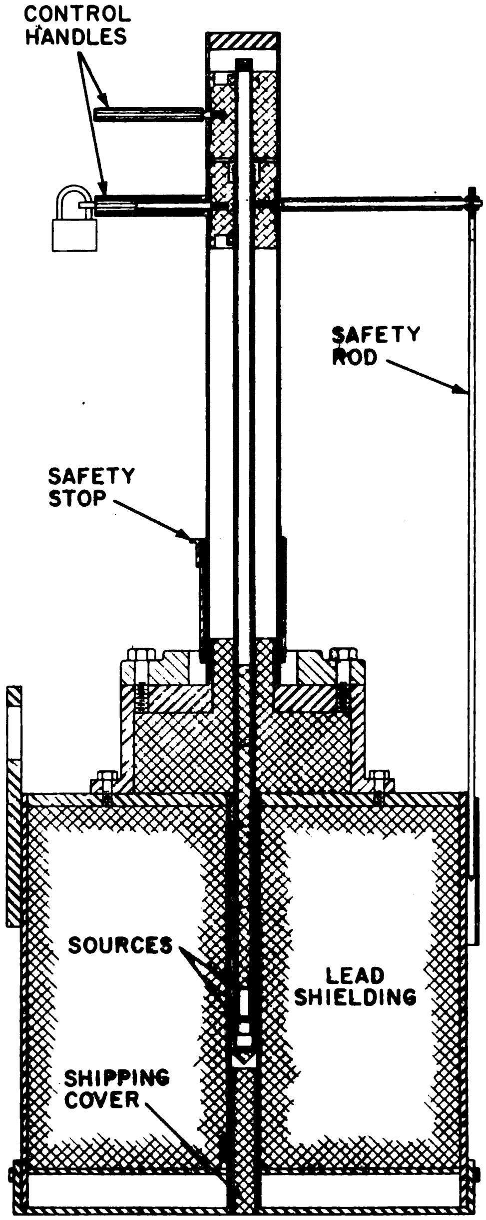


Fig. 2 Schematic drawing of radiation chamber.

water, are brought through a stepped hole in the cart.

The source storage shield is placed above the cavity and between steel blocks. It is easily removed from the chamber and can be transported to the hot laboratory for changing or loading sources.

The sources are contained at the bottoms of two concentric tubes. One or both sources can be lowered from the storage shield into the cavity below by means of the control-rod handles. An electrical interlock prevents lowering of the sources unless the cart is fully inserted. When the sources are lowered, the cart is mechanically locked in place to prevent its accidental withdrawal during irradiation.

OPERATION

Samples are placed on holders which are fastened to the rotating table, and the cart is rolled into place. The 20- or 100-curie cobalt 60 source is lowered into the cavity. A spring-loaded stop, which prevents damage if the source assembly is accidentally dropped, must be rotated before the source seats on a locating centering cone.

REFERENCE DATA

Location: Argonne National Laboratory.

RADIATION CHAMBER ANL MODEL 7

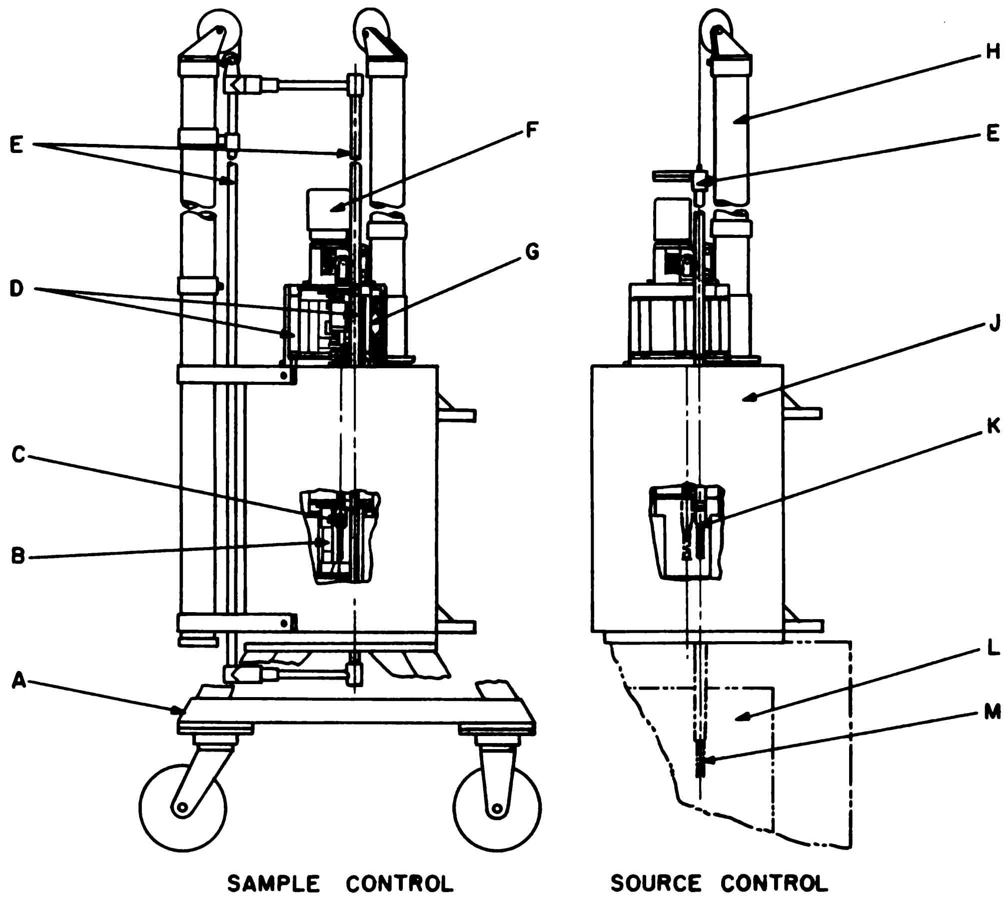


Fig. 1 Chamber (front view) used as sample control. Chamber (side view) used as source control. *A*, dolly; *B*, sample can in turret; *C*, cobalt 60 source; *D*, sample cans within magazine; *E*, yoke and source-control rod; *F*, motor; *G*, sample; *H*, hollow counterweight tube; *J*, radiation shield; *K*, retracted cobalt 60 source; *L*, external irradiation cavity; *M*, extended source position.

APPLICATION

The automatic radiation chamber model 7 was designed specifically for the study of chemical effects of gamma rays on aqueous solutions using a 5000-curie cobalt 60 source. Irradiation of solids or biological systems can also be performed in ⅞-in.-diameter by 6-in.-long sample cans or by using the chamber as a source control with an external irradiation cavity.

DESCRIPTION

The shield (Fig. 1) is 18 in. in diameter by 28 in. high and weighs approximately 3000 lb. The top plug of the shield, to which all the inner and outer mechanism is mounted, is lead-filled. The dolly base is 35 in. square and contains all the shield projections. The over-all height of the unit is 8 ft.

The yoke or source-control rod is driven at a

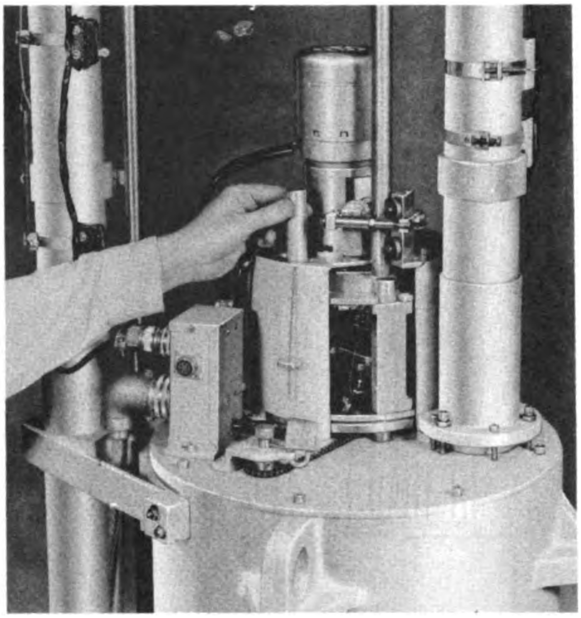


Fig. 2 Top of chamber showing sample can being placed in magazine.

speed of 2.4 ips by a motor mounted over the magazine. The motor torque is twice that required, and the motor can be stalled without damage. The drives and position-indication switches for the magazine and turret are located in the center of the magazine assembly. The turret is rotated at a speed of 3 rpm during the irradiation period.

The source is usually located in the center of the turret but can be driven by a rack and pinion into position in line with the source-control rod to make connection with it. The source can then be lowered into an auxiliary irradiation cavity. The yoke and yoke counterweight assembly is removed when using the chamber as a source-control unit.

Two types of sample cans are used. One type will rotate about its own axis as it is rotated in the turret around the source; while the other will always face the source with a known side.

OPERATION

The chamber is mounted on a dolly and is remotely controlled from a panel (not illustrated). The panel has individual timers for each sample loaded in the six-position turret and will unload samples automatically at the end of a preset time. Additional samples can be loaded by manual push-button control in any empty position of the turret during a program irradiation.

When the chamber is used for source control with an auxiliary irradiation cavity, one of the irradiation timers will automatically raise the source into the shield.

REFERENCE DATA

Location: Argonne National Laboratory.

Reference Drawings: Chamber RCD-317; Source RCD-437.

HIGH-LEVEL GAMMA ROOM

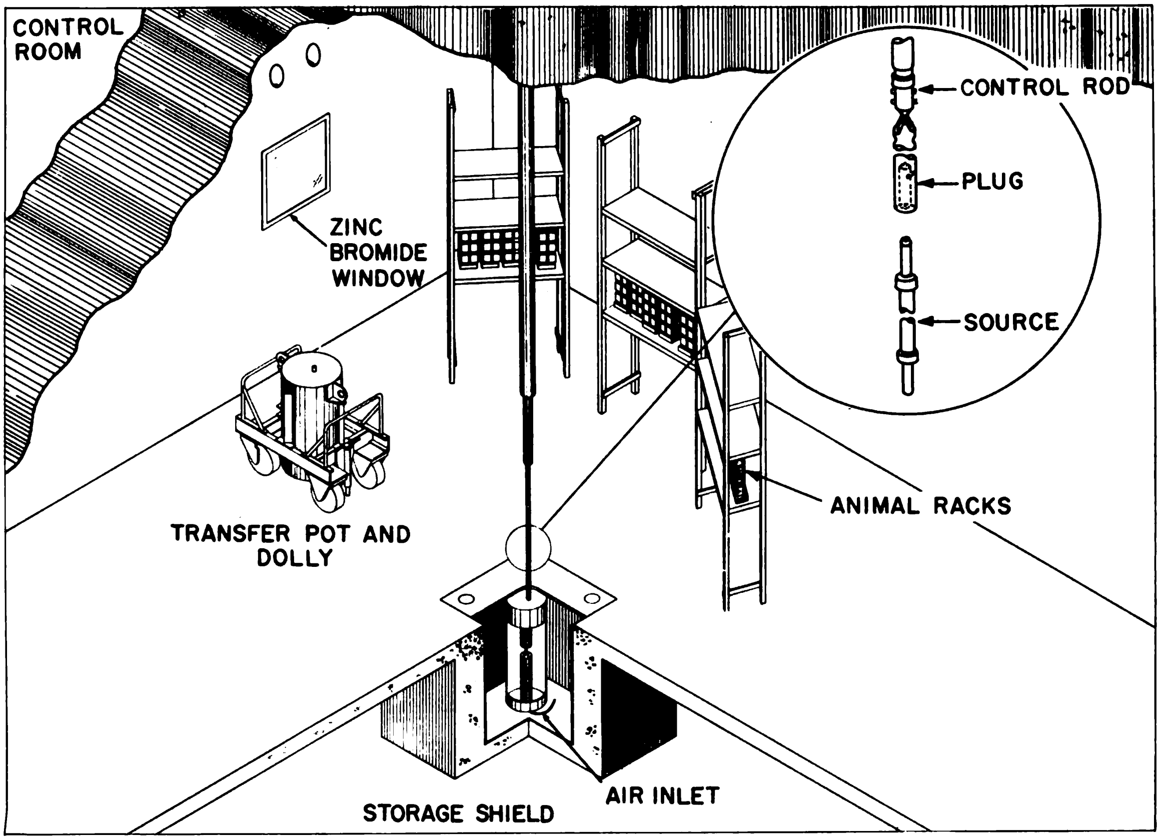


Fig. 1 Gamma-radiation room for biological studies.

APPLICATION

The high-level gamma room is an irradiation facility that was built primarily for radiation studies using cobalt 60 sources in biological and medical research. As it is a large room with the source at the center, a complete isodose curve can be obtained from one experimental setup.

The specimens to be irradiated are arranged at different distances from the source, previously determined by accurate dosimetry measurements. Specimens are mounted on tables or racks, as shown in the illustrations. The large room and the arrangement of specimens on the isodose curve are such that the backscatter obtained is not a problem.

DESCRIPTION

The room is 24 ft square with an 18-ft ceiling. Entrance to the room is by a doubly stepped labyrinth at one corner. The storage shield is set in a pit in the floor with provisions for storing four cobalt sources, ½ in. diameter and 14 in. long, in a remotely controlled turret. Several thousand curie sources can be used for irradiation experiments with the shielding provided.

A plug (Fig. 1) is attached mechanically to the control rod mounted from the ceiling. The plug and control rod operate in a guide tube connected at the floor to the storage shield. The plug shields the hole of the storage shield when the control rod is down. By disconnecting the

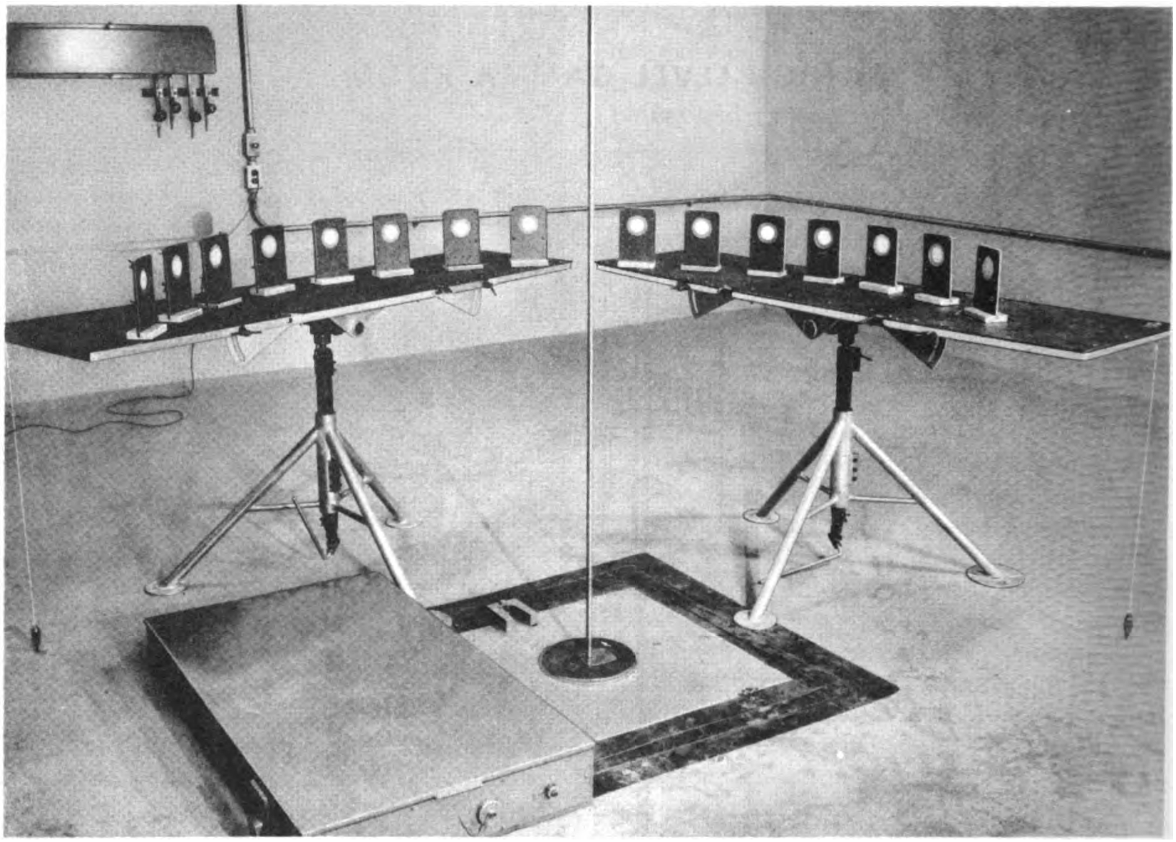


Fig. 2 Biology-culture experimental-irradiation setup.

guide tube and the control rod the transfer pot can be positioned over the storage shield for loading or unloading the sources without additional shielding.

The source can be positioned from floor level to a height of 6 ft by adjusting the control rod.

OPERATION

The turret is positioned so that the source selected is lined up with the exit hole of the storage shield. The control rod and shield plug are raised to the selected height. The source is raised by pneumatic action and held to the control rod and plug by a mechanical catch. Air pressure automatically releases the source at the end of the prescribed irradiation time. The control rod travels down through the guide tube and, as a safety precaution, is interlocked with the entrance gate. In addition, equipment is provided for constantly monitoring the room.

REFERENCE DATA

Location: Argonne National Laboratory.
Reference Drawing: RCD-301.

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